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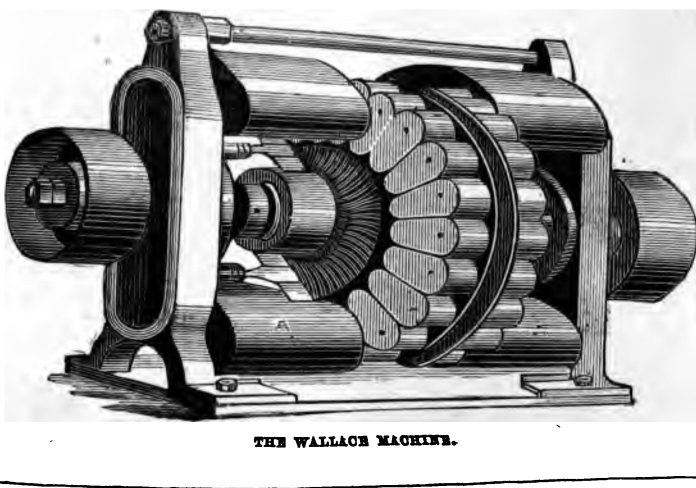
YEAR-3

THE JABLOCHKOFF CANDLE.

THE GRAMME MACHINE.

THE JABLOCHKOFF CHANDELIER.



THE WALLACE MACHINE.

THE APPARATUS OF ELECTRIC LIGHTING.—See p. 169.

THE

YEAR-BOOK OF FACTS

IN

SCIENCE AND THE ARTS

FOR

1877/78

1878.

BY

JAMES MASON.

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PREFACE.

THE period covered by the present "Year-Book of Facts" will ever be memorable in the annals of Science. The extraordinary inventions of the Microphone and Phonograph, following that of the Telephone, recorded in our volume of last year; the Liquefaction of the "Permanent" Gases, and the practical application of the Electric Light, would suffice of themselves to make any year famous.

These Facts, with a host of others of great interest and importance, are fully recorded in the following pages. The plan of this Year-Book is the same as that of its predecessors. The last volume ended with the 15th of October, 1877. This one begins with that date, and is brought down to the 15th of October, 1878. The work, we are certain, will be found not to have in any way fallen off in value, and we now place it, with a lively feeling of gratitude for so long continued support, in the hands of the public.

WARWICK HOUSE, SALISBURY SQUARE,
24th December, 1878.

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THE

YEAR-BOOK OF FACTS.

I.—THE HUMAN RACE.

Notes on the Tribes of Midian.—A paper, entitled "Notes on the Tribes of Midian," was read at the Dublin Meeting of the British Association by Captain R. F. Burton. The country, he said, once belonged to the Moabites, Ammonites, and Amalekites of Scripture; but the tribes now inhabiting it were comparatively modern. They were a mixed race. The tribes were given to exaggerating their numbers, with the view of extorting the more blackmail from pilgrims. The whole land of Arabia was supposed to belong to some one tribe or another of Bedouins, so that if all the members of a tribe, save one boy, should be destroyed, he would be deemed entitled to the land of his forefathers. The history of these tribes was a history of plundering and quarrelling with each other, although it would not be true to say that they were habitual thieves and murderers. The custom prevailed of pressing the heads of children after birth. On the seventh day after a birth there was a feast if the child was a boy; but girls did not count. The practice of tattooing existed among them. He believed it to be a practice used by nations who had not much clothing for the purpose of hardening the skin.

The paper described the manner in which young girls were given in marriage, and stated that girls had been known to commit suicide rather than marry men whom they disliked. Some of the higher classes were decidedly handsome. Longevity was rare among them, in consequence of incessant fatigue, indifferent nourishment, and want of cleanliness. Their characteristics were strong social affections, eternal suspiciousness, extreme pugnacity, and proportionate revengefulness. Their sociability was extreme, and they made great sacrifices for one another. The small-pox had replaced the plague among them, and when a man was attacked he was shut up in a solitary hut, and food and water were pushed in to him with a stick. But in many cases the female relations and friends joined in the quarantine.

Murder, as among all the primitive races, was a private and not a public wrong; the price of a man's blood was about £160. The races in question were marvellously ready to quarrel, without the excuse of being in their cups, for they had nothing to drink; but they tried to avoid killing

each other lest they should have to pay blood money. They were excessively ceremonious. If they hated Christians, it was more on theoretical than any other grounds. Nature put it out of their power to obey the Koran. They did not fast, they said, because they were half-starved all the year round. Englishmen could manage them, but the Ottomans never could, for the Bedouins hated the Turks and Egyptians, and were, in turn, despised by them. Those who lived on the coast fished for pearl and black coral. They eat the flesh of the shark; but he had tried it boiled, roasted, and stewed, and found it anything but good. As to their cooking, all he could say about it was that they never washed anything. They were unalphabetical, and, consequently, had no literature. They improvised verses, and the circumstance of his having a fur coat made him the subject of the following stanza:—

> "O Sheik, wearer of the costly fur,
> Whither thou leadest us, thither we will go."

Composite Portraits.—A paper "On Composite Portraits, made by combining those of various Persons into a single Resultant Figure," was read on the 30th April, 1878, before the Anthropological Institute, by Mr. Francis Galton. The author remarked that when images of many different persons are successively thrown for a short time on the same portion of a sensitive photographic plate, the composite figure that results is found to have an unexpectedly good definition. No person who saw one of these composites for the first time would doubt its being the likeness of a real person, whereas it is no such thing; it represents the average of many. Of course the component images must all be in the same attitude and of the same size, but exactitude in other respects is unnecessary. The important requisite is that the images should be carefully superimposed, and this is a very easy matter to effect.

The author begins by collecting photographs of persons of the same general type of features, and taken in the same attitudes. These are reduced photographically to the same size, then they are severally adjusted under fixed cross wires, until one wire cuts the pupils of the eyes and the other bisects the interval between them. Then a hinged arm, carrying two points, is pressed down and pricks two register marks. When all the portraits have been thus prepared they are hung one in front of the other on two pins sticking out of a screen in front of the camera, and passing through their register holes. They are photographed successively by removing one after the other to the last. Suppose there are ten component portraits, and that it would require 100 seconds exposure to get a satisfactory image of any one of them, then each of the ten portraits is exposed ten seconds only. The composite retains what is common to all the components, while individual peculiarities have in it no perceptible trace; the result is a handsome and regular face. Many specimens were exhibited. Even two faces will often make a fair combination. but the larger the number the

better, if they all have the same general cast of features.

The uses of the process are to procure anthropological types, to compare the average likeness of a family of brothers and sisters with that of their near ancestry—viz., two parents, four grandparents, and the uncles and aunts on both sides; and to obtain a good likeness of the same person by averaging many portraits. The author exhibited methods of optically combining portraits. A stereoscope will do this in a way, but the best instrument for the purpose is a "double image prism" of Iceland spar.

On Left-Handedness.—A paper "On Left-Handedness" was read before the British Association at their Dublin meeting, by Dr. H. Muirhead. He had been drawn to pay some attention to left-handedness in reference to its hereditariness in families. The human family were in general right-handed. No instance had been brought forward of a left-handed tribe or race. The oldest pictorial illustrations that they knew of did not differ in this respect from the story of to-day. Why was man right-handed? It had been said that man was best able to balance himself on his right leg and foot, and if that were so he would naturally be better able to use his right arm in offence or defence. If this were so it would account for the left-hand side of the brain becoming more influential. There were, of course, some exceptions to the rule of right-handedness. A theory had been put forward to the effect that the choice of hands depends upon the relatively preponderating weight of the upper or lower part of the body, but he thought it depended on which half of the brain took the lead. Left-handedness once begun in a family was likely to run in it. It was very common in the tribe of Benjamin. It was a curious fact that left-handed people had the left foot one-eighth to one-third of an inch longer than the right.

An Expiring Race.—"A Note on an Expiring Race on the Bhutan Frontier of Hindustan," by Mr. S. Dumont Beaghton, was read at the Dublin meeting of the British Association. The author gave a vivid description of the hills on the frontier, on one of the highest peaks of which was supposed to rest a temple not made with hands, and a tank of Sacred Water, which, the natives said, could not be removed without death. He made attempts to get up on the rock, and on one occasion nearly lost his life by stepping over a precipice. The people who were the subject of the paper, the Fotos, lived in the village called the Orange-grove, near the top of the hills. There were only about 20 females, and within two or three generations (as they only married among their scanty limits), it may be confidently predicted that the race will disappear. Their language was so difficult that none of the other tribes could pronounce a word of it. They had traditions which pointed to a retrogression from a higher scale of nations, and their belief was that, from the time they became coweaters, they became degraded. They belonged originally to the aborigines who lived in the Gangetic valley be-

fore the Aryan dispersion. They were gloomy and fatalistic as a rule; very thin; their noses very flat, and their lips projecting so as almost to suggest a Negritic origin. They wore red jackets next the skin, with under sleeves. They showed little of the Aryan fastidiousness in matters of food. Every youth was permitted to marry as soon as he had a home and means, and they alone among the frontier tribes treated marriage as a sacrament. The bridegroom had to give presents to his mother-in-law, and feast the whole village on roast pig. No celebration was allowed when a child ate rice for the first time. No little interest attached to them if they were a remnant of the people who occupied Bengal before its subjugation by Aryan civilization.

The Native Races of North America.—An interesting paper was read at the Dublin meeting of the British Association by Professor Daniel Wilson, F.R.S.E., of the Toronto University, containing illustrations of the evolution of new varieties of men. In the mingling of different races in America, so complex and varied, all subjected to the influences of climate and social habits, and all mingling in blood in a greater or less degree with the native red races, hybridity had resulted on a great scale. The process had already been developed sufficiently long to afford important indications of the evolutions of permanent hybrid varieties. A specimen is to be seen among the tribes of the half-breeds in Manitoba, as it were, in the process of evolution; while sheltered within the remote *Arctic* regions man can be studied among the Esquimaux in conditions closely analogous to those which are ascribed to a post-pliocene, if not to a pre-glacial period. In the abrupt collision of the civilized races of Europe with the American aborigines it had always been taken for granted that the latter were doomed to inevitable extinction, and that the land would be peopled with the purely civilized races of the world. There is no question, however, that from an early date there have been intermarriages between Europeans and the American races. A growing feeling is manifesting itself in the United States and Canada that the Indian population is not doomed to extinction, and that a much larger amount of healthy intermarrying, and consequent absorption, has existed than unobserving critics had any conception of, and that the native Indian element is a factor in the population of the New World destined to exercise an enduring influence on the ethnical character of the Euro-American races.

The Size of the Brain.—At the Anthropological Congress in Paris of 1878, Dr. Lebon gave the results of his experimental researches on the variations of volume of the cranium in relation to intelligence. According to observations made on numerous series of crania, it is proved that intelligence is in proportion to the volume of the cranium, the best endowed races, and among races the most intelligent individuals, having the most voluminous cranium. By comparing these series of crania it is also found that the superior races present a much greater number of volumin-

ous crania than the others. The same phenomenon is presented in proportion to the degree of civilization; the Parisian crania of the 12th century present, for example, a less volume than the crania of modern Parisians; at the same time the difference among individuals becomes more considerable. Dr. Lebon does not believe that height exercises any considerable influence on the volume of the cranium and the weight of the brain. Nevertheless, with equal height, the woman has a brain less heavy than the man. The author, from a study of 17 male and 17 female brains, found between them a difference of 172 grammes to the advantage of the former. It is worthy of remark that among the superior races the cranium of the woman is generally much less than among the inferior races. This is due, Dr. Lebon says, to the insignificant part taken by woman in the work of modern society. The comparative study of the curves of the circumference of the cranium, of that of the head, of the volume and weight of the brain, shows the relations existing between these various values, and renders possible the construction of tables which, one of them being known, permit the immediate determination of the others of the series. It is seen, for example, that a head, the circumference of which is 57 centimètres, corresponds to a cranium the circumference of which is 52 centimètres, and the volume 1,550 cubic centimètres. The probable weight of the brain contained in the cranium would be 1,350 grammes. There is a constant inequality of development between the two halves of the brain, which is sometimes more developed on the right, sometimes on the left, without race or state of intelligence appearing to have any manifest influence on the direction of this inequality of development. The circumference of the cranium, on which depends the volume of the brain, has a close connexion with the degree of intelligence. With the measurements of the circumference of the head, taken from more than 1,200 living subjects, Dr. Lebon has constructed a series of curves which show that from the point of view of their development the heads of modern Parisians and of the inhabitants of the country are classed in the following order:—1. Savants and learned men; 2, The Parisian *bourgéoisie*; 3. The Old Nobility; 4, Parisian Domestic Servants; 5. Peasants. Dr. Broca, in remarking on Dr. Lebon's paper, said that if among the less civilised races the difference between the volume of the crania of men and women is relatively small, while it is great among civilized races, this does not prove the intellectual inferiority of women, but is explained by the necessity for savage women taking part in the struggle for existence under the same conditions as the men.

The Natives of Tasmania.—A scientific work on the Tasmanian aborigines was published in the early part of 1878 by MM. de Quatrefages and Hamy. This race, which, in 1642, when Tasman discovered the island, is supposed to have numbered about 7,000, is now known to be extinct. The progress towards extinction may be

dated from about 70 years ago, when the first penal settlement was formed in the island. The material the authors had to work upon in their researches were portraits, photographs, busts, 54 skulls, and six skeletons. The Tasmanians seem to have been a special race, and one remarkably homogeneous, though the languages were often so distinct as to be incomprehensible by different tribes. The average capacity of cranium is 1,420 cubic centimètres, which would place the Tasmanians considerably above the Nubian negroes, though the latter are socially much superior. This feature—volume of brain—must not be too rigidly connected with intellectual development. M. Hamy further shows that the Tasmanian cranium had not those supposed signs of inferiority which have been too much insisted on. An abstract of these researches is given in *Comptes Rendus*, March 25, 1878.

The Flint Implements of Egypt and Midian.—A paper "On the Flint Implements of Egypt and Midian" was read at the Dublin meeting of the British Association by Captain R. F. Burton. Most people, he said, were aware of the dispute between naturalists and Egyptologists. The latter declared that there was no such thing as infancy of art in Egypt, and the naturalists, as was their evil habit, found signs of the commencement and origin of things everywhere. It was a very pretty quarrel as it stood. While literary men were debating, practical men found stones in every direction, even around Cairo itself. He exhibited flints, most of which were chipped, and which were found in great numbers, but Bedouins are now making them in enormous quantities and selling them to travellers. He first visited El Hawaii in March, 1877, and then proceeded to the Pyramid, the most southern of the great cemetery of Memphis, and in the King's Chamber were found two prehistoric weapons. Captain Burton exhibited a number of worked stones, cowries from Thebes, ornamented glass, and the coins of Midian, which were for the first time brought to England. Near the chief town of Midian they came across a coin which showed that even in those days there were "smashers," and was an imitation tetradrachma. It had the owl and the flower on it, but instead of being made of silver it was made of copper, with a slight layer of silver outside.

The Capacity of Crania.—A paper on this subject, already spoken of (*see* p. 4), was read at the Dublin meeting of the British Association by Prof. W. H. Flower. Of all the measurements by which to determine the difference between the human skulls of people of one race and of a foreign race, perhaps the most important was that which gave the cubic capacity of the great cavity of the skull which contained the brain. Many ways of ascertaining it had been tried. Some persons laid great stress on the weight of the brain, but for his part he thought that, on the whole, if the capacity of the skull could be got it would be more valuable. The weight of the brain differed very much according to the age or physical conditions of the person when he died,

and there were certain diseases which went to increase the specific gravity. But when the actual capacity of skull was found they had the actual capacity of the brain at the time of health. The weight of the brain could not be ascertained in cases where the races had become extinct, such as the Tasmanians, many of the Polynesians, the ancient Britons, and the ancient Irish, and others, specimens of whose skulls they possessed, and by which they could ascertain the capacity of the brain.

He might be asked if he attributed any great and direct importance to the weight and age of the brain as an indication of intelligence. Well, he thought it was one of the very many points that had to be considered in this question; but he thought there were a great many other things to be remembered in this view of the question. For instance, many people had large brains and did not know how to use them, and some who knew how to use them did not try to do it. They would see that many of the races that were naturally considered the higher races, and had taken the lead in the civilisation of the world, had undoubtedly larger cranial capacities than the peoples who were at the bottom of the ladder of civilisation. Of course he would never accept the mere fact of a man's head being large as an indication of superior intelligence, but it was one point to be considered.

The measurement of the skull was not only an important but it was also a difficult work—more difficult, in fact, than a great many people supposed. A large number of measurements published were only of an approximate value owing to the numerous fallacies and difficulties experienced in arriving at a satisfactory method of measurement. Nothing apparently could be easier than to take a skull and stop the cavities, and pour some fluid into it, and then pour it out and measure it; but they could not do this with the skull, as the bone was very porous, and full of minute invisible holes, through which the fluid soaked as it would through a sponge. The materials that had to be used in testing the capacity of the skull must be something solid. Various things, such as shot, grain &c., had been used.

Beautiful Types of Womankind.—The following is a translation of a circular issued in the summer of 1878, by Prof. G. de Mortillet, with reference to a proposed album of the most beautiful types of women:—"Desirous of studying anthropology from an æsthetic point of view, I am collecting in an album photographs of the most beautiful types of women of all countries and of all races. This collection of beauties is the more important, scientifically, that the most beautiful persons in each race ought to be the most typical, if the law of selection is real. My studies in palæo-ethnology and prehistoric anthropology have shown me that woman has played the greatest part in the progress of civilization and in the softening of manners. Man from all time has had strength as his share. Woman has ruled over and refined this nearly always brutal strength by the irresistible influence of the

heart, of grace, and of beauty. It is impossible to put in evidence all that there is of good in woman, but it can be shown to what point beauty has been raised, and thus what is and must have been from all time its power may be explained. The album I am forming, a sort of *livre d'or* of beauty, will aid in completing the demonstration based on the observation of facts. To render this album as complete and as perfect as possible, I appeal to all persons who can furnish me with documents. The collection will be composed of uncoloured photographs only, from carte-de-visite size to picture size. The medium dimensions are preferable. The indication of the name and social position of the persons is very useful, if it can be given without indiscretion. What is indispensable is to know the place of birth, the nationality, and the race. Is the race pure, or are the father and mother of different nations and races? The names of the donors, and also their addresses, when they desire it, shall be indicated. It is just that photographers should have the profit of their works. All communications should be addressed to M. G. de Mortillet, au Château de St. Germain-en-Laye (Seine-et-Oise); or at the Exhibition of Anthropological Sciences, Paris." Though M. de Mortillet's pardonable enthusiasm gave occasion for satirical remarks in a Paris paper, there can be no manner of doubt as to the interest and instruction such a collection, scientifically arranged by so distinguished an anthropologist, will afford.

Science amongst Hatters and Shoemakers.—A scientific inquiry made in the close of 1877 by Dr. Delaunay among the hatters of Paris offers some curious results. Accepting it as true that the capacity of the cranium and development of the brain are proportional to the external volume of the head, also that the intelligence is proportional to the volume and weight of the brain, he shows, *inter alia*, that certain families develop like individuals—that is, they have a period of growth, then a stationary period, then a period of decrease, previous to extinction. In families in the first period the head enlarges from generation to generation. The citizens who wrought the revolution of 1789 had bigger heads than their fathers. On the other hand, in families that are nearing extinction the head grows smaller. The sons of the present ruling families in France have such small heads—according to the author—that they require hats specially made for them. Among certain families newly risen from the common people the head increases from generation to generation. The wide-brimmed hats—bolivars—worn by the Republicans from 1830 to 1848 were very capacious. The quarter in which are the largest heads in Paris is that of the schools. The hatters of the Faubourg St. Germain say they only fit fine heads. The Polytechnicians have larger heads than the St. Cyrians, and the students of the normal school larger than those of St. Sulpice, &c. The members of the clergy present a peculiar feature in

these statistics. "In general," says M. Delaunay, "men from thirty to forty years of age have larger heads than those from twenty to thirty. Not so with ecclesiastics, for their heads cease to grow at about twenty-five. The curés, bishops, archbishops, &c., have no larger heads than the students of the large seminaries.

After these inquiries among the Parisian hatters regarding the head, Dr. Delaunay went to the shoemakers and studied the foot. He was led to think that the foot is longer, flatter, and less arched in inferior races. The Nubians, Arabs, and Japanese have the foot flat and long. In the English, among Europeans, the foot (he says) is long, thin, and flat; in the Germans, it is long, thick, flat, and flabby. On the other hand, the foot of the French is short, small, elegant, and arched. This is, no doubt, flattering to the French; the objection, however, occurs that Spaniards and Portuguese, who are not generally thought more advanced than other European people, have a well-arched foot. He meets this difficulty by saying that the evolution of the foot may be accomplished when that of the head is still incomplete or arrested. In Paris, M. Delaunay finds differences in the feet in different quarters, and he states, not without satisfaction, that ecclesiastics are at the bottom of the scale, while students are at the top. Thus there is opposition between the volume of the head and that of the foot. The small heads of the Quartier Saint Sulpice have the foot large, and the large heads of the Quartier Saint Michel have the foot fine. M. Delaunay explains the fashion of high heels by the desire to conceal the flatness of the feet, which, he says, is common in the old ruling classes that are in course of degeneration.—*English Mechanic.*

The North American Indians.—One of the most interesting papers read in the Anthropological Section at the Dublin meeting of the British Association was by Professor Daniel Wilson, of Toronto, on the Canadian Indians (*see* p. 4). Professor Wilson showed that the Canadian Indians, instead of "melting away" before the civilized virtues and vices of the white man, have already been to a considerable extent absorbed, and the likelihood is that ultimately this absorption will be complete. At present, Professor Wilson maintains—and he has so mastered the subject that he has a right to speak—that the blood of the so-called "red man" flows in the veins of every class of Canadian, from the highest to the lowest; and many of those who are treated by the Government as "Indians" are as white as many of their "pale-faced" fellow-countrymen. This subject of the fate of the American Indian has been also engaging the attention of competent men in the United States, and the facts and statistics which have been collected appear to give the death-blow to the commonly accepted "blight" and "withering" theory.

An extremely interesting paper on the subject, recently published, by Lieutenant-Colonel Mallery, enters into the question of the

former and present number of the Indians in so thorough a manner as to give confidence in the conclusions come to. Colonel Mallery, from his position on the United States Survey, has had every opportunity of acquiring a knowledge of the present condition and number of the Indians, and he has taken great pains to become acquainted with whatever records exist as to their past numbers. Colonel Mallery shows that the estimates of earlier writers are so varied as to be untrustworthy. Early travellers had no opportunity whatever of acquiring a knowledge of the Indian population of the North American Continent, but naturally would exaggerate the number of those with whom they came into contact. Naturally, also, the natives from a wide district would crowd to the shores of the sea, river, or lake, which were the first visitors' only highways, and thus the latter would be led to form an exaggerated notion of the extent of the whole population. Colonel Mallery shows that before and long after the advent of the whites, the only regions where the Indians could find support were along the shores of the great rivers and lakes. If the successive waves of continental migration did originate on the Pacific Coast, it is scarcely to be supposed that they crossed the arid plains only lately explored, or even the more eastern prairies, where, with all then existing facilities, the support of life would have been most difficult. The savages relied at first mainly on fish, secondarily and later on the *chase,* and, only in their last stages of development, on agriculture, which, though a greater resource among some tribes than is generally understood, became so after their long continued occupancy of regions near the Atlantic and great lakes. They could neither, before obtaining the horse, pursue to great advantage the large game of the open prairie necessary for their subsistence while passing it, nor transport stores before collected, and moved probably (as one route, others being also contended for) *viâ* the head waters of the Mississippi and the outlet of Lake Superior, resting on long lines and with little lateral spread, near rivers, lakes, and the ocean. The greater parts of the districts east of the Rocky Mountains and some to their west, where the Indians are now, or in recent years have been found, and much of which was until recently charted as the "Great American Desert," was, in fact, a solitude when America was discovered, the population being then confined to the wooded borders of the traversing streams. Colonel Mallery adduces irrefutable evidence to prove that many Indian tribes now classed as Prairie Indians were, when first met with and for long after, lake and river Indians. Early voyagers on the Mississippi and Lake Michigan met Indians only after many days', and even weeks', travel. Vermont and Western Massachusetts and much of New Hampshire were left unoccupied. On early maps the low country from the Mobile River to Florida was marked vacant, and the oldest reports from Georgia assert

with gratulation that there were scarcely any savages within 400 miles of Savannah. Colonel Mallery adduces many other facts which, when grouped together, show how insignificant was the territory actually occupied by the natives before the European immigrants could possibly have affected their numbers or distribution, and how silly are any estimates obviously influenced by a calculation of the product of their number on some one square mile, multiplied by the figures expressing all the square miles embraced between the Atlantic and Pacific and certain degrees of latitude. The mounds of the Mississippi Valley certainly prove that at some time it held a large population; but the origin and period, connections, and fate of these so-called "Moundbuilders" are still *sub judice*. It is, however, conceded that they were agricultural, had several arts unknown to the historic tribes, and had passed away before the latter had come within our knowledge. The ethnologists and philologists, though so widely disagreeing in other respects, both admit that the actual distribution of the natives at the time of, and shortly after, their discovery, was as represented by Colonel Mallery, and the immediate practical inquiry concerns the tribes then and still known to us, rather than ancient inhabitants, whether or not the ancestors of these tribes.

This distribution rendered misconception of their numbers by the early whites almost unavoidable. The latter, using the natural and only readily available highways of ocean and river, met the Indians precisely where they were most numerous and stationary, and could not thoroughly explore the endless tracts where they only occasionally roamed, or which they entirely avoided; while the enormous distances of separation prevented any one traveller from actually seeing, and thereby distinguishing between, but a limited number of tribes. Even if an expedition through the wilderness were risked, the very presence of the explorers, from obvious motives of curiosity, barter, or defence, would, as we have said, attract all the bands over many miles. Cunning and vanity, moreover, would induce every tribe to exaggerate its own importance, which there was at first no evidence to contradict. So late as 1829, Naw-Kaw, a Winnebago chief, attending a balloon ascent in the Battery in New York, where there was an immense crowd, and being asked if he had ever seen so many people together, replied haughtily, "We have more in our smallest villages." Considering that his whole tribe only mustered then about 3,000 souls, this may pass as a creditable specimen of aboriginal brag, which, if Government officials had not already become familiar through systematic fraud with the actual count of the Winnebagoes, would doubtless have been adopted as a faithful comparison to influence statistics, as has actually occurred with other chiefs, who, likening their few score warriors to "the leaves of the forest," have been seriously quoted. The early travellers received such tales with alacrity, to

enhance their own adventures, repeating them with the fabled reproductiveness of the three black crows, even when they did not imitate Falstaff in the multiplication of his men in buckram. Another potent cause of error in the enumeration of the Indians, extending even to modern times, and from which we are scarcely yet free, necessarily arose from the utterly confused synonyms. Not only had each of the tribes a variety of names among themselves, but the various English, French, and Dutch immigrants added to these names of their own coining, so that one tribe might have a dozen different names, and each name has often been mistakenly held to apply to a different tribe.

The main explanations of the lately unquestioned law, dooming all the American Indians to speedy death, have been in their constant wars and the strange diseases introduced. As regards the latter small-pox has been the most fatal; but Colonel Mallery shows that its ravages have been no greater among the Indians than among other races and other lands which recovered from it. Moreover, these ravages have been greatly exaggerated often, as may be seen from the report of the Canadian Minister of the Interior for 1876. In 1868 it was stated the Indians of Vancouver's Island had been nearly exterminated from small-pox, and that "hundreds of bodies lay unburied." After a full inquiry it was found that only 88 Indians had died from the disease in the whole district throughout the entire year. The fact is that many Indians have died of small-pox, as did many Europeans before the days of Lady Mary Wortley Montagu and Dr. Jenner, and also that those who could ran away from the danger, as more enlightened people do now, with the difference that the latter are brought back by the ties of real and personal property, which, not troubling the former, they ever after avoided a locality that in their theory of disease was the scene of demoniac wrath. It may be noted that this particular disease has ceased to be a scourge to the tribes, the reports of 56 agents in recent years not including any fatal case.

As to the destructive element of war, that was the normal condition of the Indians before the advent of the whites, who only added to the number of the combatants. The whites did not introduce extermination and dispossession, which were systematically carried out before they came by one or two of the most powerful tribes. The whites were never more systematic or successful in subjugation by force of arms than were several of the Indian leagues, and all we know of the prevailing customs of the continent tells us that war was with its natives a necessity for the assertion of manhood, if not a religious duty. Perhaps since the power of the white race has been established with restraining effect, there have been fewer and less bloody wars than were frequent for centuries before, and certainly for years past no whole tribe, and but a minority of individuals among very few of the tribes, have been on the war path

against any other in the United States. No such conversion, then, from less to greater combativeness is apparent as would account for any important change in the Indian population. If warfare has been a chief cause of their decrease, they were on the wane long prior to their discovery. Of this, however, there is no evidence. Taking the Iroquois as a representative body of Indians, Colonel Mallery shows that they now number 13,668 souls, as against 11,650, 13 years before the Declaration of Independence, being an increase of 2,000. This is not a solitary instance; and especially among the hybrids of Canada, New York, the Indian Territory, Massachusetts, and Wisconsin, has there been a steady increase during the past 30 or 40 years. Figures are given to show that the Sioux Confederacy have quadrupled in 140 years, and doubled, at least, in 29 years. Remarkable increase is shown in other tribes, notwithstanding war, disease, and whisky. It is at the same time admitted that in some of the western regions, especially California, the unusual barbarity of the brutal white has told seriously on the Indian population there, though not to nearly so great an extent as vague estimates would make out.

Only within the past four years has there been any official report of the births and deaths among several tribes sufficiently general to be of value. These official returns relate to over 100,000 Indians, belonging to nearly 100 tribes, and the excess of births over deaths was found to vary from 6-10ths to 2·32 per cent. Again, in former times only the strongest survived, weak children not being allowed to live, and old and diseased persons being often put out of the way. Only one of twins was allowed to survive, and generally the battle of life was only to the strong. Now, since the United States Government protect and subsidize the Indians, the latter are acute enough to see that it is to their interest to have as many mouths to feed and bodies to clothe as possible, and act accordingly.

Colonel Mallery then, from the *data* which he has collected, comes to the conclusion that when Columbus discovered America there were not more than 500,000 Indians to the north of Mexico, and that now, in the United States and Alaska alone, excluding Canada, there are something like 300,000. If the Canadian Indians and hybrids were added to this it would probably turn out that the native population had not at least decreased. At all events it seems to us that Colonel Mallery has adduced strong reasons for hesitating to accept the "blight" and "withering" theory, for the American Indians at least. That it does apply to other races with which the Anglo-Saxon at least has come into contact, there is only too good reason to believe. The last of the Tasmanians has gone, the years of the Sandwich Islanders are numbered, many other Pacific islands have been almost depopulated. As to Australia, we wish some one would do for it what Colonel Mallery has done for

North America. We believe the results for South America, if the native population question were carefully examined, would show that there also the decrease has been greatly exaggerated. To make a sweeping generalization as to the inevitable disappearance of black before white is absurd; what would be the use of Africa to the world if this were so? As to the future of the American Indian, both Colonel Mallery and Professor Wilson speak hopefully. The process of breaking in the savage to civilized ways of life must be slow. It cannot be done *per saltum.* How long did it take the European conglomeration of tribes to settle down and reach their present state of culture? In Canada many so-called Indians are really as settled and civilized as the English peasant, perhaps, on the whole, more so; and if the Indians in the States had as fair play as their Canadian brethren, the process would be much more rapid than it is. At all events, the theory of disappearance by extinction seems now a most improbable one, and that by absorption is proved to be actually occurring. Indeed, the old, old drama which has been acted in Europe from the time of the cave-men until even now is being continued on the other side of the Atlantic; and the result a century or two hence may be a race more mixed, perhaps, than any in the old world, but with the English type of character dominant, and by its very mixture better able to cope with the conditions which prevail on a continent so different in many respects from Eurasia. Professor Huxley has shown how absurd it is to talk of purity of race; there is no such thing probably anywhere in the world, least of all in Europe, in whose population there are lower strains than even that of the North American Indian. We may state that some of the most eminent scientific inquirers in the United States share Colonel Mallery's opinions as to the increase of the Indians.

Colonel Mallery disperses a few other delusions with regard to the North American Indian, most people's idea of whom is derived from Cooper's fictions. He shows how they got their name of "Red Men"—from the fact that they were in the constant habit of colouring their faces with the ochre found in the soil. Their real colour is brown, with many shades. No more common notion exists with regard to the Indians than their belief in one "Great Spirit," under names like Manitou, Taku Wakau, &c. A better acquaintance with Indian traditions, and particularly with the etymology of its languages, shows that this also is a great delusion. The more learned missionaries are now not only agreed that a general creator or upholder never existed in aboriginal cosmogony, but that the much simpler belief in a superhuman Great Chief or ruler is a modern graft. However unpleasant from a sentimental point of view, Colonel Mallery has done good service by his researches in abolishing beliefs which are so unfounded, and some of which are apt to be mischievous in their consequences—especially in these days of scientific accuracy.—*Times.*

The Population of the Earth.—The fifth publication of Behm and Wagner's "Bevolkerung der Erde" appeared in July, 1878, unfortunately a few days too soon to contain the new arrangement in the East. Since the fourth publication, the population of the earth shows a total increase of 15 millions, partly arising from natural growth and partly the outcome of new and more exact censuses. The total population is now set down at 1,439,145,300, divided among the continents as follows: Europe, 312,398,480; Asia, 831 millions; Africa, 205,219,500; Australia and Polynesia, 4,411,300; America, 86,116,000. The following table gives the latest results for the chief countries in the world:—

EUROPE.

Germany, 1875	42,727,360
Austria-Hungary, 1876	37,350,000
Liechtenstein, 1876	8,664
Switzerland, 1876	2,759,854
Netherlands, 1876	3,865,456
Luxemburg, 1875	205,158
European Russia, 1872	72,392,770
Finland, 1875	1,912,647
Sweden, 1876	4,429,713
Norway, 1875	1,807.555
Denmark, 1876	1,903,000
Belgium, 1876	5,336,185
France, 1876	36,905,788
Great Britain, 1878	34,242,966
Faroes, 1876	10,600
Iceland, 1876	71,300
Spain (without Canaries), 1871	16,526,511
Andorre	12,000
Gibraltar, 1873	25,143
Portugal (with Azores), 1875	4,319,284
Italy, 1876	27,769,475
European Turkey (before division)	9,573,000
Roumania, 1873...	5,073,000
Servia, 1876...	1,366,923
Montenegro	185,000
Greece, 1870...	1,457,894
Malta, 1873	145,604

ASIA.

Siberia, 1873	3,440,362
Russian Central Asia	4,505,876
Turcoman Region	175,000
Khiva	700,000
Bokhara	2,030,000
Karategin	100,000
Caucasia, 1876.	5,391,744
Asiatic Turkey	17,880,000
Samos, 1877	35,873
Arabia (independent)	3,700,000
Aden, 1872	22,707
Persia	6,000,000
Afghanistan	4,000.000
Kafirstan	300,000
Beloochistan	350,000
China proper	405,000,000
Chinese borderlands, including Eastern Turkestan and Djungaria	29,580,000
Hongkong, 1876	139,144
Macao, 1871...	71,834
Japan, 1874...	33,623,373
British India within British Burmah, 1872...	188,421,264
Native States	48,110,200
Himalaya States	3,300,000
French Settlements, 1875 ...	271,460
Portuguese do.	444,617
Ceylon, 1875...	2,459,542
Laccadives and Maldives ...	156,800
British Burmah, 1871	2,747,148
Manipur	126,000
Burmah...	4,000,000
Siam	5,750,000
Annam	21,000,000
French Cochin China, 1875 ...	1,600,000
Cambodia	890,000
Malacca (independent)	209,000
Straits Settlements...	308,097
East Indian Islands	34,051,900

AUSTRALIA, &c.

New South Wales, 1876	630,848
Victoria, 1876	841,988
South Australia, 1876	229,630
Queensland, 1876	187,100
West Australia, 1876	27,321
Tasmania, 1876...	105,484
New Zealand and Chatham, 1876	444,545
Rest of Polynesia	1,896,090

We have no space for details as to Africa. In 1877 Algeria had 2,867,626 inhabitants. The population of Egypt is now estimated at 17 millions, and the equatorial regions of Africa at 44 millions. Caffre-land north of the Transvaal is estimated at a million; Orange River Free State, 65,000; the Transvaal, 275,000; Natal (in 1875), 326,959 inhabitants; and Cape Colony, 1,148,462. In Ame-

rica the figures are but little changed from those of the previous issue of these statistics. Greenland (1876) is estimated to have a population of 10,000; Nicaragua (1877), 300,000; Brazil (1872), 11,108,291; Guiana (1875), 342,300; Ecuador(1875)1,066,000; Peru (1876), three millions; Chili (1875),2,333,568; Uruguay (1876), 445,000; Paraguay(1876),293,844.

Official Rank in China.—It is not generally known, we are told by the *China Mail*, of Hongkong, that official rank is, to a certain extent, hereditary in China. Thus, when an officer of the first rank dies—the four grand secretaries, viceroys, and chief presidents of the "boards" at Pekin, for instance—his sons inherit the "full fifth" rank, and are entitled to commence their public career as *Langchung*, or junior lord, of one of the boards. The sons of officers of the "full-second rank"—such as vice-presidents of the boards and governors—may enter public life as assistant-secretaries, with the "half-fifth" rank. The sons of officers of the "half-second" rank become under-assistants, with "full-sixth" rank, The sons of officers of the third rank obtain the honorary degree of bachelor of arts, carrying the seventh rank. The sons of deceased officers of lower grades inherit no rank.

The Origin and Superiority of the White Race.—This is curiously accounted for by the Seminole Indians. They believe that when the Great Spirit made the earth he created three white men, and taking them to a lake bade them leap in and wash. One *obeyed* immediately, and came out whiter than before; the second hesitated, and when he sprang in the water had become muddled, and he emerged copper-coloured; while the third delayed until the water was thick with mud, and gave him a black complexion. Then the Great Spirit gave the three men three packages, and in pity allowed the black man the first choice. He selected the heaviest, wherein he found all the implements of labour, prophetic of slavery; the copper-coloured man chose the next weightiest, which contained hunting, fishing, and warlike apparatus; and the white man was left with the lightest package, which concealed pens, ink, and paper—the emblems of civilisation, and the foundation of his superiority.

A Paradise of Gluttons.—A Paradise of Gluttons is a heaven believed in by a Sclavonic tribe of Moravia, the Hanaques. In the regions of future bliss they picture an immense mountain of crumbled gingerbread, surrounded at the base by a river of melted lard. The happy Hanaques will recline full-length on the shore, lying on their faces, with the chin supported on their hands, and into their wide-open mouths will fall balls of flour, which have been cooked by angels in the crater of the mountain, and have been rolled down the slope into the river, so as to obtain a luscious coating of gingerbread and lard. Meanwhile angels will chant the national airs, and there will be a perpetual downpour of beer and brandy, which will not wet the Hanaques, but will only fall into their mouths when they are thirsty.

II.—THE ANIMAL WORLD.

The Stings of Bees.—An account of his investigations on the subject of stings has been given by Mr. J. D. Hyatt, President of the New York Microscopic Society. These studies have extended over a period of eight years, but only recently have some obscure points been made out. The general form of the stinging organs of the honey-bee is well known to microscopists. It consists of a horny sheath, within which there are two stings, and these, when in use, are thrust out. There is a poison-bag, which discharges its contents into the sheath. This is a point well known, but it appears that the precise method by which the fluid makes its way from the sheath into the wound has not heretofore been properly explained. According to the generally accepted explanation, the poison is supposed to flow in a channel formed between the two piercers or stings, and in this way makes its way into the wound. Mr. Hyatt advances another hypothesis, and believes he has positive proof he is right, having dissected and examined upwards of a thousand stings. On examining a properly prepared sting from a honey-bee we notice first that the piercers are very sharp, and barbed for some distance from the end, there being nine barbs pointing upward on each one. These barbs are gracefully curved, and it can easily be seen that when once they find their way into the flesh it would be difficult to withdraw them. This explains why the honey-bee sting remains in the flesh, while the stings of other insects, with finer barbs, are withdrawn. A more careful observation indicates that the stings are tubes. There appears to be a channel running through the length of each one, having branches which terminate in the notches just above the barbs. After careful study of these channels, many of which were found to contain air or water after mounting, and were thus proved to be veritable channels, the question arose as to their use. The natural inference would be that they were ducts for the poison, but there could be found no possible connection between the poison-gland and these channels, for, as already stated, the poison flows into the sheath. After long and patient investigation, the explanation offered is as follows:—At the back part of the sting these channels open into the sheath, and just in front of that opening, attached to the stings, is a sort of valve which projects into the sheath. When, in the operation of stinging, the piercers are thrust out, they carry forward this valve, so as to close the front of the sheath, for which purpose they are admirably adapted, and the poison thus confined within the sheath makes its way out through these openings in the

stings. When once understood, the operation seems very simple. There are also some objections to the common explanation. Cross sections of the stings show that the walls are quite thin, but strengthened in certain places by internal deposits. The form of the stings is such that no channels can be formed between them to conduct the poison.—*Scientific American.*

Animal Life in the Far North.—An exhaustive paper "On the Geographical Distribution and Migrations of Animals on the Northern Shores and Lands of the Hudson's Bay Company, &c.," was read by Dr. J. Rae at the Dublin Meeting of the British Association. He said his intention in preparing the paper was to supplement, in some degree, the admirable writings and descriptions of his late distinguished friend, Sir J. Richardson, because he had had opportunities of visiting places which that excellent zoologist could not reach. One of the first things that struck a stranger was the regularity of the dates of arrival of migrating birds in the spring at certain localities in America. The further they went west, the wild fowl made their appearance earlier in the same latitude. At Fort Confidence, although further north than Repulse Bay, the geese arrived sixteen days earlier. Indians, both at Moose and on the Mackenzie river, some thousands of miles apart, told him that a small finch, which always made its appearance about the same time, took a passage northwards on the backs of the geese. He had never ocular proof of this, yet he could find no good reason for Indians making such a statement if it were false. The principal geese which visited Moose in the spring were of three kinds—the snow, the Edwards or blue-winged, and the Canada goose. In describing their habits, he said the geese returned from their breeding-places early in September, and spent about six weeks feeding in the marshes. It was evident that the snow and Edwards goose made a very long flight (without resting) to winter quarters when they left Hudson's Bay, because for some days before starting they appeared to eat nothing, and spent nearly all their time on the water. Their stomachs and intestines were perfectly empty, in this respect resembling salmon before commencing the arduous work of ascending a rapid river to spawn. The Canada goose, which rested on its southward flight, did not make any such preparation.

The Buzzing of Insects.—The old naturalists thought generally that the buzzing of insects was produced by the vibrations of the wing, but they had scarcely attempted to analyze this phenomenon, and their opinion was abandoned when Reaumur showed that when the wings are cut a blow-fly continues to buzz. Other explanations of the phenomenon have been advanced by various naturalists, but none of them are satisfactory. M. Jousset de Bellesme has been making some investigations on the subject, and, after proving that previous theories are unsatisfactory, he describes the results of his own researches. To avoid confusion

it should be distinctly understood what is meant by buzzing. In the scientific acceptation it means to imitate the sound of the humble-bee, which is the type of buzzing insects. But the humble-bee gives out two very different sounds, which are an octave of each other—a grave sound when it flies and a sharp sound when it alights. We say, then, that buzzing is the faculty of insects to produce two sounds at an octave. This definition limits the phenomenon to the hymenoptera and the diptera. The coleoptera often produce in flying a grave and dull sound, but they are powerless to emit the sharp sound, and consequently do not buzz. There are two or three ascertained facts which will serve as guides in the interpretation of the phenomenon. First, it is indisputable that the grave sound always accompanies the great vibrations of the wings, which serve for the translation of the insect. It is easily seen that this sound commences as soon as the wings begin to move, and that if the wings be cut off it disappears entirely. The sharp sound is never, on the contrary, produced during flight; it is only observed apart from the great vibrations of the wings when the insect alights, or when it is held so as to hinder its movement, and in that case the wing is seen to be animated by a rapid trembling. It is also produced when the wings are entirely taken away. From these two remarks we may draw the conclusion that the grave sound belongs properly to the wings, that it is caused by their movements of great amplitude. There is here no difficulty. As to the sharp sound, it is certainly not produced by the wings, since it survives the absence of these. Yet the wings participate in it and undergo a particular trembling during the production of this sound. To discover the cause it is necessary to go back to the mechanism of the movement of the wing. It is known that among nearly all insects the muscles which serve for flight are not inserted in the wing itself, but in the parts of the thorax which support it, and that it is the movement of these which acts on the wing and makes it vibrate. The form of the thorax changes with each movement of the wing under the influence of the contraction of the thoracic muscles. The muscular masses intended for flight being very powerful, this vibratory movement of the thorax is very intense, as may be proved by holding one of these insects between the fingers. But as the vibrations are repeated two or three hundred times per second, they give rise to a musical sound, which is the sharp note. In fact, the air which surrounds the thorax is set in vibration by that directly, and without the wing taking part in it. There are then two simultaneous sounds, one produced by the vibration of the wings and the other by the thoracic vibration, the latter twice as rapid as the former, and therefore an octave. This is why in flight only a single grave sound is heard. When the thorax moves alone a sharp sound is produced. This, M. de Bellesme believes, is the only explanation that can be given of the mode of production of the two sounds which constitute buzzing.

Chinese Fish in French Fish-ponds.—One of the best fishes of the Celestial Empire appears now to have been successfully acclimatised in France. It has been called variously *Hypophthalmychthys Dabryi* and *H. Molitrix*, and is a cyprinoid, which the Chinese have classed among their domestic fishes, the extensive cultivation of which is one of the most valuable sources of public alimentation in the empire. It is reared in ponds by means of aquatic herbs (such as France happily possesses), and in a short time it acquires considerable dimensions. Its weight sometimes reaches 40lb., the flesh is firm and savoury, recalling at once the taste of turbot and of trout; further, it has few bones. The first attempts which M. de Thiersans made to introduce this species into France were in 1875, when he sent from Canton, for the Société d'Acclimatation, 9,000 fry, of which nine only arrived at Marseilles. They were confided to a delegate of the society, who constructed a pond for their reception. During these four years the young fish have grown large, and appear to be flourishing. The society has given orders for a number of others to be sent, so that it is hoped the new importation will become a common ornament of ponds, and a delicacy of the table.

Physic for Grasshoppers.—Poisonous qualities are popularly attributed to the castor-oil bean, the fruit of *Ricinus communis*. According to the statements of a California newspaper, this property extends to the leaves, sufficiently to make them of use in destroying insects. By distributing the leaves where grasshoppers were numerous, great numbers of the insects were soon killed. The effect of the poison upon the grasshopper is said to be apparent very shortly after it eats a portion of a leaf. The insect seems bewildered, vainly attempts to jump or fly, and finally, tumbling over, dies.

A Song from a Mouse.—The question as to whether mice occasionally sing has been revived in France. M. Brierre described before the Society of Acclimatisation his experience in La Vendée in 1851-53. He had bought an old cupboard which happened to contain mice. About sunset the mice began to sing. By lubricating the doors and hinges of the cupboard, M. Brierre was enabled to open it in one instance without disturbing the song. He literally caught the songster in the act. It was an old mouse, which held its nose in the air like a dog when howling. Its song was like that of a wren. M. Brierre seized the mouse in his hand, but afterwards allowed it to escape. On subsequent evenings the singing was renewed. There were no birds in the house. The utterance of a less musical sound has latterly been discovered as part of the capacity of the scorpion, on the authority of Mr. J. Wood Mason, and described before the London Entomological Society. The experiments were made at Bombay, by teasing two large scorpions placed face to face on a table. The sound is stridulous, somewhat like that from scraping a stiff brush with the finger-nails. An

anatomical examination showed that the insect is provided with an apparatus consisting of a scraper and a rasp; these appendages could be made to give sound when separated from the scorpions after death.

A Herring's Appetite.—The principal food of herrings caught in the German Ocean and the Baltic consists, according to M. Mobins, of some kinds of very small crustaceans of the order of Copepoda. In February, 1872, a great many herrings were caught in Kiel Bay. Nearly all that M. Mobins opened had their stomachs full of copepoda, belonging almost exclusively to one species (*Temora longicornis*). In the full stomach of one large herring the number of these crustaceans present was, after careful counting, found to be 60,895. Another herring contained 19,170. For three weeks continuously there were taken daily in Kiel Bay about 240,000 herrings. Supposing that each of these devoured every day only 10,000 copepoda (which is putting the number very low), this would give, for one day, a consumption of 2,400 millions, and in three weeks 43,000 millions. The upper surface of the water swarmed with these minute animals, so that with fine-meshed nets they could easily be caught in thousands. These facts show that the German coasts, though they are poor in species, have enormous quantities of individual animals.

The Habits of the Field Vole.—Sir Walter Elliott, at the Dublin meeting of the British Association, made some interesting observations on the annual increase of the common vole (*Arvicola agrestis*) of late years. In the spring of 1876 they appeared in such numbers in the hill pasture farms of the Border districts between England and Scotland, and parts of Yorkshire and Wensleydale, as to destroy the grazing ground on which the sheep depended in spring, causing serious loss to the farmers by impoverishment and death of stock. The shepherds destroyed as many as they could, without sensibly diminishing their numbers, although assisted by birds and beasts of prey—hawks, buzzards, owls, weazles, foxes, &c. At the same time that the vole was doing such mischief, another species (*Arvicola arvalis*), not known in England, made its appearance in Hungary, and attacked the corn fields, which it had done to a less degree in two or three previous years, and this year they attacked the wheat fields of Moldavia. Many instances are recorded of great damage done by them, both in England and Scotland, by destroying plantations, of which Mr. Jesse described a notable instance in New Forest and Dean Forest some time ago. These examples prove that they do not confine their attacks to pastures and woods, and it is possible that they might under favourable circumstances betake themselves to our corn fields. It is therefore worth consideration whether our game preservers should not be more forbearing towards hawks, owls, and weazels, which are nearly exterminated in many places, although they live almost entirely on these and other small but destructive creatures.

The Sources of Animal Fat.—The sources of fat in the body of the higher animals has long been discussed, and a paper containing the results of a number of experiments by Messrs. Lawes and Gilbert, well known for their investigations on the feeding of animals, appeared in the close of 1877 in the *Journal of Anatomy*. Before the application of accurate chemical research to questions of this nature, it was generally held that those animals that rapidly acquired fat, such as the herbivora generally, and some kinds of birds, derived the fat that they accumulate in their bodies from the fat contained in their food. It was thought that vegetables only possessed the power of forming fat, and that animals only stored up those portions of fat which they did not consume in respiration. This doctrine was first called in question by Liebig, who maintained that a goose fed on maize accumulated after a short time much more fat on its body than was primarily contained in the grains of the Indian corn it had swallowed, and he attributed much of the fat of the body to the carbo-hydrates of the food.

The experiments of MM. Dumas and Payen, who contested Liebig's statements, showed that maize contained much more oleaginous substance than was admitted by Liebig, and that in point of fact it contained sufficient to account for the deposit of fat in the animal. Liebig, with great acumen, replied that although it was true that maize contained more fat than he had given credit for, yet *his opponents had* omitted to notice that a large proportion of the fat contained in the food was discharged in the excrements. Similar observations with similar discrepancies of opinion were made on cattle. At this juncture MM. Milne Edwards and Dumas drew attention to and repeated the experiments of Huber, showing that bees are capable of forming wax—that is to say, a kind of oleaginous substance—even when fed on pure sugar. This result was soon confirmed and generalised by the experiments of M. Boussingault on pigs, and of Parson on geese.

From this time the original theory of the immediate passage of fats already formed by vegetables into the animal, and its deposition in a more or less fluid form, was almost entirely discarded, and the production of fat in and by the animal body was very widely admitted. The general impression in England was sufficiently evidenced by the adoption of Mr. Banting's system of preventing or reducing large deposits of fat—namely, by reducing the amount of carbo-hydrates taken as food. At a meeting of the Congress of Agricultural Chemists, held in Munich in 1865, Prof. Voit came forward as the advocate of a new view. From the results of experiments with dogs made in Pattenkofer's respiration apparatus, he maintained that fat must have been produced from the transformation of the nitrogenous or albuminous constituents of the food, and further, that these were probably the chief, if not the only source of the fat, even of herbivora.

The more recent experiments of Weiske and Wildt, though some-

what unsatisfactory from the small number of animals experimented on, as well as for other reasons, tended, on the whole, to support Voit's statements. The great interest of this subject, and the importance of obtaining correct views upon it, being perceived by Messrs. Lawes and Gilbert, they undertook a careful review and recalculation of many of the results of their feeding experiments, including those with oxen, with sheep, and with pigs. The results of that inquiry are, briefly, that, so far as the ruminant animals are concerned, owing to the comparatively small amount of increase obtained in them from a given amount of constituents consumed, the quantity of nitrogenous substance passed through the system for the production of a given amount of increase was in most, if not in all, cases so large as, in the absence of proof to the contrary, to admit of the assumption that the whole of the fat formed had its source in transformed nitrogenous matter. At any rate, they satisfied themselves that no absolute proof of the derivation of fat from the carbo-hydrates could be obtained from data of this kind in relation to such animals. So far, therefore, their experiments can be interpreted in a sense favourable to Voit's views. In the case of the pig, however, the results were very different. In many of the experiments made on these animals much more fat was produced than could possibly have been derived from the albumen of the food, and hence the carbo-hydrates must have contributed directly to its formation. It would seem probable that the same conclusion holds good in the case of man. The fattening that may take place on a starchy diet, and that which is well known to occur in negroes during the sugar season, when they habitually consume a large amount of sugar, are unequivocal proofs that man, like the bee, can manufacture fat from the carbo-hydrates; but it would seem to be equally probable that he can form it from the albuminous compounds when the farinaceous and saccharine elements happen to be deficient in his ordinary diet, whilst a combination of both is certainly best adapted for the supply and maintenance of that moderate amount which should be present in every healthy person.—*Lancet.*

The Extinction of the Mammoth in Siberia.—A paper upon this subject was read at the Dublin Meeting of the British Association by Mr. H. H. Howarth, F.S.A. Mr. Howarth's principal object was to deal with the difficulties that surround the explanation as to the mode in which the animal became extinct. He said the theories hitherto propounded as to the extinction of the mammoth in Siberia were, that it lived in the central parts of Central Asia, and that the carcases were floated down the large rivers in that territory to the sites where the remains were now found. This theory may now, however, be said to be extinct. The examination of the stomach showed that the mammoth lived on larch or birch trees growing at the verge of woods, near which the remains of the animals were found, and their position showed that they had not wandered far when they were

entombed. After looking at the problem from every side, he had come to the conclusion that there had been a sudden and violent change of climate in Siberia, which had frozen the previously soft ground, and had also preserved the mammoths as in a huge meat safe. Although the mammoth had even originally lived in the place where he was now found, it was impossible that he could live there now, owing to the absence in that part of the food which would be necessary to sustain him. Such trees as he used to live on were only now found about 500 miles from the spot where his remains were discovered. The natural corollary that followed from this theory was that something similar must be postulated with regard to other regions. The conditions in which the elephant was found in Siberia were precisely similar to those in which it was found in the north-western part of Russian-America, and precisely the same as those in the Great Lakes, where the mammoth itself was found, and it could not, therefore, be doubted that the mammoth lived in Europe and America with the same food and surroundings as it did in Siberia.

Professor Leith Adams gave it as his opinion that the extinction of the mammoth, like the extinction of many other animals, was not easily accounted for; but the interpolation of a cold period might very probably have been the cause. From the thickness of the coat of the mammoth it could have survived a climate such as Canada, but he could well imagine that in a climate like that of northern Siberia it could not survive. It was rather curious, however, that the whole of them should have been swept away, and that they should not be drifted further south, where the climate was more congenial. He instanced the case of the Irish elk, 200 skulls of which were found in the Wicklow mountains in a moss a quarter of a mile long and about 200 yards broad, and which animals must have been subject to frequent accidents, such as sudden inundations. Some such fate might have befallen the mammoths.

The Development of Flounders.—At a meeting of the American Academy of Sciences, in the close of 1877, Prof. Alexander Agassiz gave the following interesting account of the growth of the flounder. The flounder in early youth has one eye on each side of the head, like other bony fishes. After three or four months, both eyes are found on one side. Steensbruck concluded, from his own observations, that one of the eyes passed through the head to the other side. Professor Agassiz has made the subject a profound study, and concludes that, in general, the eye—so to speak—slides round, instead of going through. The eye that is to change place begins by moving upward till it is nearer the dividing line and towards the snout. Then it is gradually moved, by the pull of the muscles surrounding it, around the skull and over the frontal bone, till its destination is reached. But in certain species, such as that observed by Steensbruck, the passage is made over the frontal bone, but under the dorsal fin. In these cases the dorsa

fin extends to the snout; the passage is made under the base of the fin. At the time of the movement of the eye, the bones are soft and cartilaginous, the muscles strong, and the torsion is great. It takes place within about four months after hatching.

The manner has been shown, but not the cause. The notion has been that this fish has its eyes both on one side because its facilities for securing food are thereby increased. But why should not this process have, by natural selection, resulted in a fish that, when hatched, has both eyes on the same side? We do not find this peculiarity in fossil flounders, and no flounders have yet been found later than the Tertiary formation. It is not true that all flounders are destitute of swimming bladders. There are other fishes as flat as a flounder, but with eyes on both sides of the frontal bone. The sides of the flounder in the young are identical as to colour. The colour is due to the pigment cells, of which there are three kinds, red, black, and yellow. By contraction of these cells the different colours are produced. Now, if a flounder is left in a vessel with a grey ground, it becomes grey; if on a black ground, black; if on a red ground, red. This power of changing colour is, however, lost on the side where the eye is absent. The inference is that the nervous system, being affected by a change of colour through the eye, originates the change in colour of the fish, by means of appropriate contraction of the pigment cells. But when light was continuously admitted to the under side of the vessel holding the young fish before its eye had gone to the other side, the process of development and removal of the eye to the other side went on just as before. There was a great deal yet to be learned before this series of facts could be explained.

A lively discussion ensued, and in reply to an inquiry from Prof. Marsh, Prof. Agassiz replied that the optic nerve of the fish was long and sinuous, so that it could be stretched sufficiently to enable the eye to travel to its new position. "This," said Professor Agassiz, "was certainly a wise provision of Nature, for otherwise the eye could not have been shifted." During the discussion it was mentioned that other animals — notably, cuttle-fishes—which have the power to change colour in accordance with their surrounding, sometimes make a mistake in so doing, and fail to reach the right colour. There seems to be no little room for doubt as to the popular theory of these accommodations of colour.

Animal Intelligence.—The following is an abstract of a lecture delivered by Mr. Romanes at Dublin during the meeting of the British Association:—Animal intelligence is a subject which has always been of considerable interest to philosophical minds, but, as most of you are probably aware, the interest attaching to this subject has of late years been greatly increased by the significance which it has acquired in relation to the theory of descent. As human intelligence is the only order of intelligence with which we are

directly acquainted, and it is moreover the highest order of intelligence known to science, we may most conveniently adopt it as our standard of comparison. When I allow my eyes to travel over this vast assembly, my mind receives, through their instrumentality, a countless number of impressions. So far as these impressions enter into the general stream of my consciousness, they constitute what are called perceptions. Suppose now that I were to close my eyes, and to fix my attention on the memory of some particular perception which I had just experienced—say the memory of some particular face. This mental image of a perception would be what is called an idea. Lastly, suppose that I were to analyse a number of the faces which I had perceived, I should find that, although no two of them are exactly alike, they all bear a certain general resemblance to one another. Thus, from the multitude of faces which I now perceive, it becomes possible for my mind to abstract all the essential qualities of a face as a face; and such a mental abstraction of qualities would then constitute what I might call my abstract idea of a face in general, as distinguished from my concrete idea, or memory, of any face in particular.

Thus, then, we have three stages :—1st, that of immediate perception; 2nd, that of ideal representation of particular objects; 3rd, that of a generalised conception, or abstract idea, of a number of qualities which a whole class of objects agree in possessing. It will be convenient to split the latter division into two subdivisions—viz., abstract ideas which are sufficiently simple to be developed without the aid of language, and abstract ideas which are so complex as not to admit of development without the aid of language. As an instance of the former class of abstract ideas we may take the idea of food. This is aroused in our minds by the feeling of hunger; and while the idea when thus aroused is clearly quite independent of language, it is no less clearly what is called an abstract idea. For it is by no means necessary that the idea of food which is present to the mind should be the idea of some special kind of food; on the contrary, the idea is usually that of food in general, and this idea it is which usually prompts us to seek for any kind of food in particular. Simple abstract ideas, therefore, may be formed without the assistance of language; and for this reason they are comprised within what Lewes has called the logic of feelings. But abstract ideas of a more elaborate type can only be formed by the help of words, and are therefore comprised within what Lewes has called the logic of signs.

Now, with regard to ideas themselves, I need only add that they are the psychological units which compose the whole structure intellectual. They constitute, as it were, the raw material of thought, which may be elaborated by the reflective faculty into various products of thought. Once formed they present an essential property of occurring in concatenated series; so that

the occurrence of one idea determines that of another with which it has been previously joined. This principle of the association of ideas, manifested as it is by the ultimate units of intellectual structure, is by far the most important principle in psychology; it is the principle which renders possible all the faculties of mind—memory, instinct, judgment, reason, emotion, conscience, and volition. Mr. Romanes then proceeded to give an elaborate analysis of the psychological basis of mind, and in taking leave of that part of his subject he pointed out that in recognizing the indisputable fact of mind having such a basis we are not necessarily committing ourselves to the doctrine of materialism. That psychical phenomena are very intimately associated with the physical phenomena is a fact which does not admit of one moment's dispute; but concerning the nature of this association science must declare, not merely that it is at present unknown, but that, so far as she is at present able to discern, it must for ever remain unknowable.

Passing on now to our review of comparative psychology, the first animals in which, so far as I can ascertain, we may be quite sure that reflex action is accompanied by ideation, are the insects. For Mr. Darwin has observed that bees remember the position of flowers which they have only several times visited, even though the flowers be concealed by intervening houses, &c. Sir John Lubbock also has shown that, after a very few individual experiences, bees are able to establish a definite association between particular colours on paper and food; and further that, after a very few lessons, a bee may be taught to find its way out of a glass jar. These observations would seem to prove that the grade of intelligence is higher in some articulata than it is among the lower vertebrata. For many of you will probably remember the experiment of Professor Mobius, which proved that a pike requires three months to establish an association of ideas between particular kinds of prey, and the fact of their being protected by an invisible wall. This fact was proved by the pike repeatedly dashing its nose against a glass partition in its tank in fruitless efforts to catch minnows which were confined on the other side of the partition. At the end of three months, however, the requisite association was established, and the pike, having learned that its efforts were of no use, ceased to continue them. The sheet of glass was then removed; but the now firmly established association of ideas never seems to have become disestablished, for the pike never afterwards attacked the minnows, though it fed voraciously on all other kinds of fish; from which we see that a pike is very slow in forming his ideas, and no less slow in again unforming them.

As regards the association of ideas by the higher vertebrated animals, it is only necessary to say that in all these animals, as in ourselves, this principle of association is the fundamental principle of their psychology;

that in the more intelligent animals associations are quickly formed, and when once formed are very persistent; and, in general, that so far as animal ideation goes, the laws to which it is subject are identical with those under which our own ideation is performed. Let us then ask, how far does animal ideation go? The answer is most simple, although it is usually given in a most erroneous form. It is usually said that animals do not possess the faculty of abstraction, and therefore that the distinction between animal intelligence and human intelligence consists in this—that animals are not able to form abstract ideas. But this statement is most erroneous. You will remember the distinction which I laid down between abstract ideas that may be developed by simple feelings, such as hunger, and abstract ideas that can only be developed by the aid of language. Well, remembering this distinction, we shall find that the only difference between animal intelligence and human intelligence consists in this—that animal intelligence is unable to elaborate that class of abstract ideas the formation of which depends on the faculty of speech. In other words, animals are quite as able to form abstract ideas as we are, if under abstract ideas we include general ideas of qualities which are so far simple as not to require to be fixed in our thoughts by names. For instance, if I see a fox prowling about a farmyard, I cannot doubt that he has been led by hunger to visit a place where he has *a general idea* that a number of good things are to be fallen in with, just as I myself am led by a similar impulse to visit a restaurant. And, to take only one other instance, there can be no question that animals have a generalised conception of cause and effect. For example, I had a setter dog which was greatly afraid of thunder. One day a number of apples were being shot upon the wooden floor of an apple-room, and as each bag of apples was shot it produced through the rest of the house a noise resembling that of distant thunder. My dog became terror-stricken at the sound; but as soon as I brought him to the apple-room and showed him the true cause of the noise, he became again buoyant and cheerful as usual. Another dog which I had, used to play at tossing dry bones to give them the appearance of life. As an experiment I one day attached a fine thread to a dry bone before giving him the latter to play with; and after he had tossed the bone about for a while as usual, I stood a long way off and slowly began to draw it away from him. So soon as he perceived that the bone was really moving on its own account his whole demeanour changed, and, rushing under the sofa, he waited horror-stricken to watch the uncanny spectacle of a dry bone coming to life. I have also greatly frightened this dog by blowing soap bubbles along the floor; one of these he summoned courage enough to touch with his paw, but as soon as it vanished he ran out of the room terrified at so mysterious a disappearance. Lastly, I have put

this dog into a paroxysm of fear by taking him into a room alone and silently making a series of horrible grimaces. Although I had never in my life hurt this dog, he became greatly frightened at my unusual behaviour, which so seriously conflicted with his general idea of uniformity in matters psychological.

Of course in thus claiming for animals the power of forming general conceptions, I mean only such general conceptions as can be arrived at by the logic of feelings. So far, then, as the logic of feelings can carry them, I maintain that the intellectual operations of animals are indistinguishable from those of ourselves. My friend Dr. Rae, the well-known traveller and naturalist, knew a dog in Orkney which used to accompany his master to church on alternate Sundays. To do so he had to swim a channel about a mile wide; and before taking to the water he used to run about a mile to the north when the tide was flowing, and a nearly equal distance to the south when the tide was ebbing, "almost invariably calculating his distance so well that he landed at the nearest point to the church." In his letter to me Dr. Rae continues:—"How the dog managed to calculate the strength of the spring and neap tides at their various rates of speed, and always to swim at the proper angle, is most surprising." So much, then, for judgment.

For some good instances of reasoning in animals I am also indebted to Dr. Rae. Desiring to obtain some Arctic foxes, he set various kinds of traps; but, as the foxes knew these traps from previous experience, he was unsuccessful. Accordingly he set a kind of trap with which the foxes in that part of the country were not acquainted. This consisted of a loaded gun set upon a stand pointing at the bait. A string connected the trigger of the gun with the bait, so that when the fox seized the bait he discharged the gun, and thus committed suicide. In this arrangement the gun was separated from the bait by a distance of about 30 yards, and the string which connected the trigger with the bait was concealed throughout nearly its whole distance in the snow. The gun-trap thus set was successful in killing one fox, but never in killing a second; for the foxes afterwards adopted either of two devices whereby to secure the bait without injuring themselves. One of these devices was to bite through the string at its exposed part near the trigger, and the other device was to burrow up to the bait through the snow at right angles to the line of fire, so that, although in this way they discharged the gun, they escaped with perhaps only a pellet or two in the nose. Now, both of these devices exhibited a wonderful degree of what I think must fairly be called power of reasoning. I have carefully interrogated Dr. Rae on all the circumstances of the case, and he tells me that in that part of the world traps are never set with strings; so that there can have been no special association in the foxes' minds between strings and traps. Moreover, after the death of fox

number one, the track on the snow showed that fox number two, notwithstanding the temptation offered by the bait, had expended a great deal of scientific observation on the gun before he undertook to sever the cord. Lastly, with regard to burrowing at right angles to the line of fire, Dr. Rae justly deemed this so extraordinary a circumstance that he repeated the experiment a number of times in order to satisfy himself that the direction of the burrowing was really to be attributed to thought and not to chance.

Passing on to the emotional life of animals, we find that this is very slightly, if at all, developed in the lower orders, but remarkably well developed in the higher —that is to say, the emotions are vivid and easily excited, although they are shallow and evanescent. They thus differ from those of most civilized men in being more readily aroused and more impetuous while they last, though leaving behind them but little trace of their occurrence.

As regards the particular emotions which occur among the higher animals, I can affirm from my own observations that all the following give unmistakable tokens of their presence:—Fear, affection, passionateness, pugnacity, jealousy, sympathy, pride, reverence, emulation, shame, hate, curiosity, revenge, cruelty, emotion of the ludicrous, and emotion of the beautiful. Now, this list includes nearly all the human emotions, except those which refer to religion, and to the perception of the sublime. These, *of course*, are necessarily absent in animals, because they depend upon ideas of too abstract a nature to be reached by the mind when aided by the logic of signs. Of course the moral sense as it occurs in ourselves involves ideas of high abstraction, so that in animals we can only expect to meet with a moral sense in a very rudimentary form; and, therefore, even if it is true that no indications of such a sense are to be met with in animals, the fact would not establish any difference in kind between animal intelligence and human.

But I am inclined to believe that in highly intelligent, highly sympathetic, and tolerably well-treated animals, the germ of a moral sense becomes apparent. To give an instance, a Skye terrier I had was only once in his life known to steal; and on this occasion, when very hungry, he took a cutlet from a table and carried it under a sofa. I saw him perform this act of larceny, but pretended not to have done so, and for a number of minutes he remained under the sofa with his feelings of hunger struggling against his feelings of duty. At last the latter triumphed, for he brought the stolen cutlet and laid it at my feet. Immediately after doing so, he again ran under the sofa, and from this retreat no coaxing could draw him. When I patted his head he turned away his face in a ludicrously conscience-stricken manner.

St. George Mivart has said that an interesting book might be written on the stupidity of animals. I am inclined to think that a still more interesting book might be written on the stupidity

of savages. Now there is no doubt that the interval which separates the most degraded savage from the most intelligent animal is, psychologically considered, enormous; but enormous as it is, I cannot see any evidence to show that the gulf may not have been bridged over during the countless ages of the past. Abstract ideas amongst savages are mostly confined to such as may be formed by the logic of the feelings. In comparing the intelligence of a young child with that of an adult animal we are met with this difficulty—that as the bodily powers of children at so immature an age are so insufficiently developed, the mind is not able, as in the case of animals, to accumulate the experiences of life. In order, therefore, to obtain a fair parallel, we should require a human being whose mental powers have become arrested in their development at an early age, while the bodily powers have continued to develop to mature age, so serving to supply the aborted human intelligence with full experience of life.

Now, the nearest approach that we have to these conditions is to be found in the case of idiots. As there are all degrees of idiocy, the object of my inquiry was to determine the order in which the various mental faculties become enfeebled and disappear as we descend from the higher to the lower grades of imbecility. Beginning from below, the first dawn of intelligence in the ascending scale of idiots, as in the ascending scale of animals, is invariably to be found in the power of associating simple concrete ideas. Thus there are very few idiots so destitute of intelligence that the appearance of food does not arouse in their minds the idea of eating; and, as we ascend in the scale idiotic, we find the principle of association progressively extending its influence, so that the mind is able, not only to establish a greater and greater number of special associations, but also to retain these associations with an ever-increasing power of memory. Again, the faculty of reason is dwarfed to the utmost—so much so that the investigator is most of all astonished at the poverty of rational power which may be displayed by a human mind that in most other respects seems well developed. A boy, 14 years of age, belonging to the highest class of undoubted idiots, could scarcely be called feeble-minded as regarded many of his faculties. His powers of mental calculation were quite equal to those of any average boy of his age. Yet he was not able to answer any question that involved the simplest act of reason.

From the mental condition of uneducated deaf mutes we learn the important lesson that in the absence of language the mind of a man is almost on a level with the mind of a brute in respect of its power of forming abstract ideas. I have, therefore, no hesitation in giving it as my opinion that the faculty of speech is alone the ultimate source of that enormous difference which now obtains between the mind of man and the mind of the lower animals. Is this source of difference adequate to distinguish the mind of man from the mind of the lower

animals in kind? I leave you all to answer this question for yourselves. I am satisfied with my work if I have made it clear to you that the question whether human intelligence differs from animal intelligence in kind or in degree hinges entirely on the question whether the faculty of speech has been of an origin natural or supernatural.

We are living in a generation which has witnessed a revolution of thought unparalleled in the history of our race. I do not merely allude to the fact that this is a generation in which all the sciences, without exception, have made a leap of progress such as widely to surpass all previous eras of intellectual activity; but I allude to the fact that in the special science of biology it has been reserved for us to see both the first rational enunciation, the first practical demonstration, and first universal acceptance of the doctrine of evolution. And I allude to this fact as to a fact of unparalleled importance in the history of thought, not only because I know how completely it has transformed the study of life from a mere grouping of disconnected observations to a rational tracing of fundamental principles, but also because it is now plainly to be foreseen that what the philosophy of evolution has already accomplished is but an earnest of what it is designed to achieve; and, forasmuch as this enormous change in our means of knowledge and our modes of thought has been so largely due to the almost unaided labours of a single man, I do not hesitate to say, even before so critical an audience as this, that in all the history of science there is no single name worthy of a veneration more profound than the now immortal name of Charles Darwin.

Zoological Distribution and its Difficulties.—Mr. Philip L. Sclater, M.A., Ph.D., F.R.S., the Secretary of the Zoological Society, gave a discourse at the Royal Institution, on the 15th of February, 1878. After pointing out that "locality" is quite as much a part of the characters of natural groups of animals as form and structure, he explained and illustrated "specific" and "generic" areas, and the doctrine of their continuity. He then treated of "representative species," and showed that, while insular representative species are usually distinct, continental representative species are not unfrequently found connected together by intermediate forms. The only hypothesis, he said, that will explain these and other phenomena of "distribution" is that of the derivative origin of species. But the question is, are there no exceptional cases of distribution, which throw difficulties in the way of the universal adoption of this hypothesis? It must, said the speaker, be admitted by all who have studied the distribution of species, in any group of animals, that there are many such difficult cases. The conclusion arrived at was that it is still a subject of discussion whether it is invariably safe to predicate that identity of structure in two species necessarily indicates immediate descent from a common parentage.

III.—THE WORLD OF PLANTS.

The Breath of Leaves.—The chemical composition and the functions of leaves of plants has been engaging the attention of M. Corenwinder for some years past. He describes his researches in a recent number of the *Annales de Chimie et de Physique*. His results are against the common theory that plants have two respirations, one by day, the other by night, and that these are in opposite directions. Briefly, his views are these: Leaves, in regard to air, have two distinct functions. By their protoplasm they constantly respire—*i.e.*, absorb oxygen and produce carbonic acid. By their chlorophyll, on the other hand, they "inspire" by day only carbonic acid, and "expire" oxygen. In early age protoplasm predominates in the cells, and there is little chlorophyll; thus during this period the respiratory function prevails over the chlorophyllian function, so that the leaves exhale carbonic acid without interruption. As the leaves grow larger the protoplasm diminishes, and the chlorophyll increases, so that they rapidly lose the power of emitting carbonic acid by day, and ere long they emit only oxygen. It is, then, only by placing them in the dark, or at least softening the brightness of the light—*i.e.*, suspending more or less the action of chlorophyll—that the effect of respiration can be shown. There is thus only one true respiration—the *rôle* of the chlorophyll is of a different order; it is an act of assimilation.

The Influence of Trees on Moisture. — Observations have been made in French forests by M. Fautrat, to determine the influence of trees on the distribution of rain and moisture. He finds that forests receive more rain than open plains, and pines more than leafy trees. Pines retain more than half of the water that is precipitated upon them, while leafy trees allow 58 per cent. to reach the ground. Pines, therefore, furnish the best shield against sudden inundations, and the best means for giving freshness and humidity to a dry climate.

Mushroom Culture in Japan.—The best of the edible species of mushrooms are known as "matsu-také" and "shu-také." The shu-také species have this peculiar excellence, that though they are all but tasteless in their raw state, when they are dried they have an extremely fine flavour. The quantity that grows naturally on the decayed roots or on the stumps of the shu tree is not sufficient to meet the demand felt for them, consequently much skill has been brought to bear on their cultivation, notably by cutting off the trunks of the shu and other trees, and forcing the growth of the mushroom on

them. Different varieties of oak appear to be the trees most in favour with the Japanese for the cultivation of mushrooms, the trees known to natives as shu giving the best results. Mushrooms are obtained in the following manner:—About the beginning of autumn the trunk, about 5 in. or 6 in. in diameter, of any of these trees is selected and cut up into lengths of 4 ft. or 5 ft.; each piece is then split down lengthwise into four, and on the outer bark slight incisions are either made at once with a hatchet, or the cut logs are left till the following spring, and then deep wounds 7 in. or 8 in. long are incised on them. Assuming the first course to have been pursued, the logs, after having received several slight incisions, are placed in a wood or grove where they can get the full benefit of the air and heat. In about three years they will be tolerably rotten in parts. After the more rotten parts are removed they are placed against a rack in a slanting position, and about the middle of the ensuing spring the mushrooms will come forth in abundance.

A New Mode of Cultivating Potatoes.—A new mode of cultivation of the potato, recommended by M. Calloigne, consists in placing on soil deeply dug or tilled, halves of ordinary sized potatoes at intervals of about 50 sq. ctm., or, better, entire potatoes at intervals of 75 sq. ctm., and in regular lines. The potato (which is not placed in a furrow) is covered with a light layer of earth, by means of a hoe or the like. In such good conditions of *ventilation* it is not long in penetrating the layer of mould, and after a few days it is repeatedly earthed up to accelerate the growth. This method of planting is said to give very much better results than the common method of planting in furrows, and the potato acquires its maturity before disease is declared. The potato, coming originally from Peru, a country much hotter than ours, requires (says M. Calloigne) air and heat for its development under good condition, and the earth which surrounds it can only be regarded as a support, a medium round which as much air and heat should be made to circulate as possible. To put it in a cold trench, compact and moist, is to hinder its growth and reduce its production considerably, also to subject it voluntarily to the most troublesome influences of disease.—*English Mechanic.*

The Ripening of Grapes.—The question has recently been investigated by M. Pollacci, whether grapes separated from the plant undergo an after-ripening for some time, as is the case with apples and pears. Several kinds of unripe grapes were cut off with scissors, and three portions formed of each kind. One portion was then taken, and its quantity of sugar and acid determined immediately. Of the two other portions, one was placed in shade, the other in sunshine, and after ten or twelve days the same data were procured. It appeared that there was, indeed, a small increase of sugar and decrease of acid, and the differences were greater in the case of the grapes exposed in sunlight than with those kept in shade.

The Vine Disease.—Mr. T. S. Leacock, of Madeira, recommends the following treatment for the prevention of phylloxera:—In the autumn and winter I cause the underground stem and principal roots of the vines which are to be treated to be laid bare of earth as far as can be conveniently and safely done, removing or causing to be burnt or plunged into boiling water the loose bark, which is generally teeming with insects. I then apply with a brush a coating of turpentine, in which sufficient resin has been dissolved to render it decidedly sticky. The proportion is about 3½oz. of fine powdered resin to a quart bottle of turpentine. Solution to be assisted by heat. I take this opportunity to manure the vines, so that one removal of the earth shall suffice for both operations. The roots when tolerably dry are covered with earth. The mixture kills all it comes in contact with, and in whatever other way it may act, continues to present, in consequence of its being unaffected by water, an impassable barrier to the passage of the insect to the upper world. Several thousand vines have been treated by me in this way in the course of the last two or three years, and although at the time of treatment they were teaming with phylloxera, they have thrown out strong shoots, produced good crops, and have preserved the dark green colour of their foliage through the past trying season. The cost of the mixture is trifling, and, as far as I have seen, the operation need not be repeated oftener than once in two or three years.

A Marvellous Stimulant.—Pitury is a stimulant said to be of marvellous power, and known to be used by the aborigines of Central Australia; but its origin has hitherto remained undiscovered. In February, 1878, however, after vainly endeavouring for many years to obtain a specimen of the plant, Baron Ferdinand von Müller, Director of the Botanical Gardens at Melbourne, succeeded in getting some leaves; and after careful microscopic examination he has shown that they are derived from the *Duboisia Hopwoodii*, which he described in 1861. This bush extends from the Darling River and Barcoo to West Australia, through desert scrubs, but is of exceedingly sparce occurrence anywhere. In fixing the origin of the pitury, a wide field for further inquiry is opened up, inasmuch as a second species of *Duboisia* extends in the forest-lands from the neighbourhood of Sydney to near Cape York, and has also been traced in New Caledonia, and more recently in New Guinea. In all probability the latter shares the properties of the former, as Baron von Müller finds that they both have the same burning acid taste. The natives of Central Australia chew the leaves of the pitury, just as the Peruvians and Chilians masticate those of the coca, to invigorate themselves during their long foot journeys through the deserts. Baron von Müller is not certain whether the aborigines of all districts in which the pitury grows are really aware of its stimulating power; but those living near the Barcoo travel many days' journey to obtain this, to them,

precious foliage, which they always carry about with them, broken into small fragments and tied up in little bags. The blacks use the pitury to excite their courage in warfare, and a large dose has the effect of infuriating them. It is by no means improbable that experiments may show that by this discovery a new and perhaps important medicinal plant has been gained.

Sugar in the Nectar of Flowers.—Mr. Alex. S. Wilson, M.A., B.Sc. Glasgow, read a paper at the Dublin Meeting of the British Association "On the Amounts of Sugar contained in the Nectar of various Flowers." Nectar, he said, is the sweet-tasting fluid secreted within the cups of flowers, and is intended to provide an inducement to cause insects to visit the flowers. These insects confer great benefit on the flowers by assuring their cross fertilisation, bringing pollen from other plants and depositing it on their stigmas. The result of this is that the plant is enabled to produce seeds of much greater vigour than it otherwise would. The saccharine fluid is usually contained in the most secluded portion of the flower, in order that it may be protected from the rain, for, owing to the solubility and the diffusibility of sugar, were it not so protected it would speedily be transferred to parts of the plant where it could be obtained by the insects without their serving the plant in the way of cross fertilisation. The colour, odour, and marking of flowers, enable insects to find the nectar more easily. The importance of these insects *will be apparent from* the smallness of the amounts of sugar found in the flowers experimented on by Mr. Wilson. Flowers of fuchsia yielded a total of 7·59 mm. of sugar—1·69 of this was fruit sugar, and 5·9 apparently cane sugar. Of red clover each head gave a total of 7·93 mm.—fruit 5·95, apparent cane sugar 1·98. On each head of clover there are nearly 60 distinct florets. Calculating from these results there was the industry of the bee brought out in an extraordinary manner, for in order to obtain the kilog. of sugar 7,500,000 flowers must be sucked. As honey contained, roughly, about 75 per cent. of sugar, a bee has then to make two and a half millions of visits in order to collect a fund of honey. It was rather a curious fact that nectar should contain cane sugar, seeing that honey never did—indeed, were a vendor to sell honey containing cane sugar, he would probably be prosecuted under the Adulteration Act. A change must therefore take place while the sugar is in the bee's possession—possibly through the action of the juices with which it comes in contact while in the honey-bag. As nectar is acid in its reaction, it is, however, possible that the process of inversion may take place spontaneously.

Soda in Plants.—A large number of specimens of dried or living plants (nearly 600 species) have lately been examined by M. Contejean, with reference to the soda they contained. He finds that more than three-fourths of terrestrial plants proper (non-maritime) growing in media not apparently saline, contain soda, and often a good deal of it. It is

nearly always accumulated in the subterranean part of the plant, and diminishes in amount as you proceed upwards, so that the flowers, fruits, branches, and top of the stem show no trace of it. Aquatic plants are an exception; they contain much soda in all the submerged parts; the parts rising out of the water contain much less, and often none at all. The aptitude for soda varies according to families, genera, species, and even individuals. Azotised plants (as *Lycium*, &c.) contain least; there seems to be an antipathy between soda and nitrogen, or at least between soda and nitrous and ammoniacal compounds. Non-saline soils, which do not contain lime, seem more favourable to soda-containing plants than calcareous soils. All the facts seem to indicate that soda is hurtful, or useless, to the majority of plants. The roots seem to absorb without discrimination, and by diffusion, all the soluble principles they are in contact with, and afterwards a sort of sifting takes place, which hinders the deleterious substances from penetrating into the organs where their presence might be mischievous.

The Insect Fertilisation of Flowers.—A paper "On the Association of an Inconspicuous Corolla with Proterogynous Dichogamy in Insect-fertilised Flowers," was read before the British Association meeting at Dublin, by Mr. Alex. Wilson, M.A., B.Sc. Glasgow. There is a class of flowers, represented by the common figwort (*Scrophularia nodosa*), which are shown, by their secreting nectar and emitting odours, to be dependent on the visits of insects for their fertilisation, and not on the wind, and yet they do not possess a conspicuous coloured or marked corolla for the guidance of insects to the flowers. Moreover, the flowers are in them not massed together, to gain additional conspicuousness, as in highly-coloured flowers, like heaths, foxglove, gladiolus, &c. Highly-coloured conspicuous flowers are usually proteranthous—*i.e.*, the anthers are matured before the stigma, and, as flowers are usually developed from below upwards, it follows that in any given plant the lower flowers will have shed their pollen and have their stigmas ready to receive it by the time the upper flowers are beginning to shed their pollen. In this inconspicuous class, on the other hand, the lower flowers will be in the second or male stage when the upper flowers are as yet in the younger or female stage. Now it is clear that an insect visiting such flowers must adhere to the habit of the bee, which invariably begins at the lowest flower on a stalk and goes upward, taking each flower in regular succession. By this means it invariably enters first a female flower, and there deposits the pollen it brings with it from another plant. Were the bee to reverse this order, the whole elaborate arrangements of many plants for cross-fertilisation would be upset, for the bee would simply transfer pollen from the upper male flowers and deposit it on the lower female ones. This would be fertilisation by flowers of the same plant, and this Mr. Darwin has shown to be little or no better than self-fer-

tilisation. In the case of the inconspicuous flowers, where the opposite condition obtains, a bee would frustrate fertilisation by adhering to its ordinary ascending habit. Mr. Wilson's observations of a wasp visiting these plants indicate that the wasp begins at the top flower and proceeds downwards — so that they are adapted specially to such insects; and as wasps are generally predatory in their habits, and not entirely vegetable feeders, as bees are, it is probable that, like other carnivorous creatures, their perceptions of vision and scent are keener; hence wasps can probably find these obscure flowers quite as easily as a bee can a highly-coloured one. The plant, therefore, finds that the material can be more economically utilised than in the production of a coloured corolla, just as in the case of self-fertile cleistogamic flowers.

The Distribution of Plants in North America.—Sir Joseph D. Hooker, K.C.S.I., President of the Royal Society, delivered a discourse on the Distribution of Plants in North America, on the 12th of April, 1878. He began by mentioning numerous instances of the dissemination of plants by emigration. Thus, on arriving in New England last summer, he found at once more than 250 old England plants which had displaced natives, and the same in warmer regions. He then pointed out on the map how in the Arctic regions the three northern continents approach, a fact which favours the assumption that they were formerly connected; and he then commented on the chief geographical features of North America. The Arctic American flora was stated to be on the whole uniform, with genera and species not found eastward or westward, and partly that of Greenland. South of this are the British possessions, which contain a mixture of the floras of Northern Europe, Asia and America. It is on entering the United States that the flora of temperate North America attains its great development. Thus, the great eastern forest region, extending over half the continent, consists of immense numbers of mixed deciduous and evergreen trees. In a patch, a few miles from St. Louis, on the Missouri, in less than a mile's space, Sir Joseph counted 40 kinds of timber trees (oaks, maples, elms, &c.) and about 20 kinds of shrubs; and even in the little Goat Island, at the cataract of Niagara, he found 30 kinds of trees. In no temperate region of the globe is there such an aggregation. The speaker then, referring to a diagram in which a line was drawn at about 40 deg. North latitude, proceeded, going westward, to characterise the flora of the grassy prairies, followed by that of the Rocky Mountains of Colorado, a grassed and loosely timbered coniferous region, with cacti below and an alpine region above; then came the great Salt Lake, a saline region nearly treeless; and, last, the great coniferous region of the Sierra Nevada and the valley of California, heavily timbered with chiefly evergreen trees.

Sir Joseph then expounded the geological and climatic reasons,

based upon the researches of Mr. Darwin, Dr. Asa Gray, and himself, for the presence in the North American flora of Asiatic and Scandinavian plants, and the mode of their distribution, referring to detailed evidence. He concluded with an interesting account of the two giants of the vegetable kingdom — the "redwood" (*Sequoia sempervirens*) and the "big tree," Wellingtonia (*Sequoia gigantea*). Their fossil remains are found in miocene beds in high latitudes round the globe. The redwood, in a dense forest, skirts the ocean for about 500 miles, attaining an enormous height and girth; it affects a warm shore. The "big tree" endures a cooler climate, as on the Sierra Nevada. A "big tree" recently felled was 107 ft. in girth, and its estimated age was 6,400 years—more probably, Sir Joseph thought, 3,500. The average height of these trees at full age was given at 275 ft. (the maximum, 320 ft.); the girth at 6 ft. above the ground, 70 ft. (maximum, 120 ft.); the maximum age, 4,000 years. A few of the most magnificent groves of the "big trees" are protected by the State, but the rest are being ruthlessly and wantonly destroyed by fire and the saw. The Anglo-Saxon exterminates what he cannot use, and spares neither young nor old; and possibly the present generation, which witnessed the discovery of the "big tree," the noblest of the noble coniferous race, may live to say of it that the place which knew it knows it no more.

The Progress of Botany.—In the Bible there is mention made of about fifty plants distinctly determined, and about fifty others designated in more general terms. The works of Hippocrates mention 234 vegetable plants, and those of Theophrastus about 500. Dioscorides knew more than 600, and 800 names of natural plants are met with in the "Natural History" of Pliny. We have some data regarding the plants cultivated during the time of Charlemagne, and in the feudal manors, in which crossing introduced some improvements. But it is, properly, in the time of the Renaissance that botany, like all the sciences of observation and the technical arts, began to make rapid advancement.

In the sixteenth century we find 800 plants in the works of Conrad Gerner; 1,400 in those of Charles de l'Escluse; 2,731 in the "Historia Generalis Plantarum" of J. Dalechamps, in 1587; 6,000 in the "Pinax Theatri Botanici" of Gaspard Bauhin.

The seventeenth century is marked by the works of Tournefort (1694). He knew 10,146 species; he was the first to arrange them in genera—694 in number.

In the eighteenth century the immortal Charles Linnæus, the founder of botanic nomenclature, had, at the end of his life, defined 7,294 plants, distributed in 1,239 genera.

In the nineteenth century, according to the "Synopsis Plantarum" of Persoon, there were known, in 1825, from 25,000 to 26,000 species, comprising the lowest forms of moulds, and all that was contained in herbaria. In 1819, P. de Candolle, in the second edition of his "Théorié Elemen-

taire de Botanique," estimated at 30,000 the number of species then known scientifically. In 1824, Stuedel, in his "Nomenclator Britannicus," gives 70,649 names of plants, ranged in 3,933 genera; the second edition of this catalogue brings the number up to 78,000, arranged in 6,722 genera; but these numbers apply to names existing in science rather than to things existing in nature. The "Hortus Britannicus of Loudon," of 1839, enumerates 31,731 species, in 3,732 genera. In 1845 Laséque reckons the plants known at 95,000, and in 1846 John Lindley divides them into 66,435 dicotyledons and 13,952 monocotyledons. Etienne Endlicher, in his "Genera Plantarum" (1836-1840), describes 6,895 genera known in the plant kingdom, comprising fossils—or only 6,135 now living, and 240 families. In 1853 J. Lindley ("Vegetable Kingdom") estimates the genera at 8,931, and the species at 92,920. In 1863, Bentley estimates the species known at 125,000. This last number may probably be doubled when herbarising shall have been accomplished all over the earth. Meanwhile we may estimate the whole of what is now known at 60,000 dicotyledons, 20,000 monocotyledons, and 40,000 cryptogams — or about 150,000 species, distributed in 8,000 genera. On the other hand, in the first half of this century the number of species cultivated was raised, in round numbers, from 10,000 to 30,000, and it may be supposed that the catalogue of plants now cultivated would comprehend something like 40,000 botanical species, not counting races and varieties. According to this estimate there will be 10,000 species to be added to the "Hortus" of 1839, or a round number of 250 to 300 species for each year, which agrees, it appears, with the number which may be found directly—thus, the list prepared by M. André de Vos, of nothing but ornamental plants described or figured for the first time in the year 1876, contains no fewer than 175 new names.—*La Nature.*

IV.—GEOGRAPHICAL NOTES AND TRAVELLERS' TALES.

The Best Route for High Latitudes.—Dr. Rae delivered an essay at the Dublin Meeting of the British Association, on the best route to attain a high northern latitude, or the Pole itself. He reviewed the progress and results of previous expeditions, referring particularly to the Nares expedition. Sailing vessels found difficulty in penetrating beyond latitude 82°, unless when there was a gale of wind from the south. Calm weather was the best for navigating the ice-floes. Arrived at the point reached by Parry, further advance might be made with sledges. Mr. Gordon Bennett, of the *New York Herald*, intended sending out two ships in 1879 to attempt to reach the Pole from opposite directions, one going to Spitzbergen, and the other by Behring's Straits. They might meet at the Pole. Admiral Richards, in a letter to *The Times*, said he should not be surprised to see Captain Adams, of whaling notoriety, go in his Arctic ships right through Smith's Sound and out at the other side, but that speculation was made before Nares saw the ice. Previous to his expedition a great many wild ideas had been expressed. It was a mistake to say there was not the least difficulty in going to the Pole with sledges. It should be borne in mind that the journey was about 1,400 miles. Sir Leopold M'Clintock had done good service among the Parry Islands, using sledges, but he did not go more than 500 miles from his ship. His object was to show that a broad channel was a better route to reach a high northern latitude than narrow channels such as Smith's Sound, because in narrow channels the ice almost invariably infringed on one point or another, influenced by the action of winds and currents. The danger of navigating narrow channels was illustrated by the loss of no fewer than nine ships. No properly equipped steamships had ever attempted, as far as he knew, to push to the north along the west coast of Spitzbergen. He considered it essential for a fair test of the Spitzbergen route to have a properly equipped steamship sent, because here, if anywhere, steam power was requisite owing to the constant southern drift, and calm weather being the most favourable time to penetrate the ice, when a sailing vessel was perfectly helpless. The thick ice spoken of by recent explorers, instead of being a danger to a ship was rather the reverse, as, it drawing much more water than the ship did, she found an easy passage between the ice and the shore.

Mountain Climbing in British

Guiana.—An expedition was undertaken early in 1878, by Mr. Bodham-Whetham and a companion, with the view of endeavouring to scale the famous Mount Roraima in the far interior of British Guiana, on the Venezuelan frontier. Starting from Georgetown, they proceeded first up the Essequibo River, then up the Mazaruni to the Carabung, which they followed as far as the Macrebah Falls; and there the hardships of their journey began. After a toilsome march, they approached the Marima mountain, and then made the best of their way across the savannah to the neighbouring pile, Mount Roraima. Massive and grand the mountain loomed up before them—an immense parallelogram, some eight miles by six, rising in a sheer precipitous wall to a height of over 1,200 feet above its lower and wood-clad portion, The angles of the parallelogram are sharp and clear, and the walls in some places are crenellated with quaint devices. On the south and east is a stony savannah; but the rest of the mountain is encompassed by a deep and almost inaccessible ravine. Every effort was made during the eight days the travellers spent near the mountain to find a track among the fissures on its face; but in every case a hopeless plumb-line of wall was reached, without a chink or a ridge to cling to, and without a vestige of bushes that might have aided a daring climber. The summit is amply covered with vegetation; but from certain circumstances, Mr. Bodham-Whetham and his companion came to the *conclusion that* there is no lake on it, as has sometimes been supposed.—*Academy.*

On the Fly River.—An expedition was recently undertaken by Signor D'Albertis up the Fly River, New Guinea. It was carried out under very great difficulties. He experienced constant hostility on the part of the natives, and was much troubled by the conduct of some of his crew. In many places the natives were found to be very numerous, and on one day he estimates that he saw 2,000 on the banks. On that occasion he passed a large village where there were more than 500 people on the bank, whom he describes as "beautifully dressed with white feathers, and their bodies painted in many colours." They wore white shells for purposes of ornament and protection, and had "head-dresses of white feathers of cacatua and red and yellow Paradise bird." Signor D'Albertis discovered a large tributary entering the Fly River from the north-east.

Improvements in Ceylon.—As regards Ceylon, we learn from an address delivered by Sir W. H. Gregory, the governor, that great improvements have been made in that fertile island: jungle and swamp have been converted into rice-fields or lakes; in Kandy there is a constant water-supply: fountains are set up in the villages: laws are in force for preservation of the forests, of the deer, buffalo, and elephant: the pearl oyster, after some years' disappearance, has returned to the shores: a breakwater is in course of building which will convert the open roadstead of Colombo into a safe harbour,

accessible to large ships at all seasons, and it is thought that in time Ceylon will become the great free port of the East.

In New Granada.—Mr. J. Bennett, late United States Consul at Bogota, gave an account of his journey up the Magdalena River, and subsequent life in the heart of the Andes, at a meeting of the United States Geographical Society on the 17th of December, 1877. The Magdalena, Mr. Bennett explained, takes its rise in the Andes, near the frontier of Ecuador, is about 900 miles long, and is navigable 600 miles from the sea up to the rapids, and also 150 miles above the rapids. He incidentally described Carthagena, which, he said, is the most magnificently walled city in America, and which was founded in 1533. The walls had stood the test of earthquake without breach, crack, or injury, while several other parts of the city had been severely shaken. The harbour, about seven miles long, is the most beautiful on the continent, and the city itself is the great *entrepôt* of South America. The population at one time was about 50,000, but at present, Mr. Bennett says, it is not more than 20,000. The Magdalena he describes as in places two or three miles wide, the currents flowing lazily in some parts of it, but being generally as rapid as the current of the Mississippi at New Orleans. It flows for the most part through one of the richest and most prolific of countries. In the earlier part of their journey they found that the sugar cane, corn, and tobacco received some cultivation, but that all the tropical plants grew along its banks almost without attention. The climate was always that of spring or summer, but it suffered from all the disadvantages of the tropics. Their boatmen, for instance, were obliged to pole the conveyance used on the river up stream for 32 days in a temperature of 120 degs. For their completed service they received 14 dols. each, or less than 50 cents a day. Often during the day the heat went up to 130 degs., while the attacks from insects were unendurable.

The people were of the quality which one might expect to find in such a climate. Nothing surprised them but an earthquake. They would walk out to be shot without a murmur, but work they would not if it could possibly be postponed. If a new garment became necessary, they would wash as much gold from the earth as was required to purchase it, but they would not wash any more than was absolutely necessary. Mr. Bennett described graphically the malarial districts at the foot of the rapids, the tumultuous torrents of the rapids themselves, the navigation of the Upper Magdalena, upon which is the Santa Anna silver mine, worked by an English company, the glorious prospects which he beheld in the ascent of the Andes to the tableland upon which is the city of Bogota, over 8,000 ft. above the sea, while the mountains in turn towered above it 2,500 ft. He spoke in the highest terms of the politeness, refinement, and hospitality of the community, and said that the moral tone was much superior to that existing in the cities of the States. Nobody,

Guiana.—As an expedition was un-[illegible] in 1884 by Mr. [illegible] and a com-[illegible] of endea-[illegible] famous Mount [illegible] far interior of [illegible] the Venezue-[illegible] first up the Ma-[illegible] which [illegible] up the Ma-[illegible] Carabana [illegible] as far as the [illegible] and there the hard-[illegible] journey began. [illegible] march, they ap-[illegible] Marima mountain. [illegible] the best of their [illegible] the savannah to the [illegible] Mount Roraima. [illegible] the mountain [illegible] them—an im-[illegible] some eight [illegible] in a sheer pre-[illegible] height of over [illegible] its lower and [illegible] portion. The angles of [illegible] parallelogram are sharp and clear, and the walls in some places are crenellated with quaint devices. On the south and east is a stony savannah; but the rest of the mountain is [illegible] by a deep and [illegible] inaccessible ra-vine. [illegible] was made [illegible] the [illegible] during [illegible] vellers [illegible] to find [illegible] on it [illegible] hop[illegible]

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he said, need want friends in Bogota, unless he did not deserve them.

The Nyassa.—A lecture was delivered in the spring of 1878, before the Society of Arts, Adelphi, by Mr. H. B. Cotterill, upon the prospects of commerce and colonization in the region of the Nyassa. Admiral Ommanny presided, and in introducing the lecturer said that Mr. Cotterill had just returned from Africa, where he had gone over many hundreds of miles never before travelled by Europeans. The lecturer urged that it was England's duty not to waste more money and life in useless exploration, but to use zeal, common sense, and money in securing footholds and centres for civilizing influences. This had been done to some extent at the Nyassa. He sketched the suppression of the slave trade on the coast line, and stated that the word "suppression" exactly expressed the circumstances of the case. The trade was scotched, but by no means dead. Were the pressure put upon the trade relaxed, slavery would again revive. Not until England's influence was felt in the interior would the death-blow to the trade be given. The advantages which the Nyassa offered for commencing beneficial influences upon the interior were that there existed a great lake settlement; the accessibility of the Nyassa both by land and water, as compared with other lakes; the magnificent waterway supplied by the Nyassa itself to the very heart of the continent, and the commanding position that any settlement at the north end of the Nyassa would hold.

With two comparatively short breaks, it was shown by the map that up the centre of the continent there was a continuous waterway connection from the delta of the Zambesi to the delta of the Nile. It was true that African rivers were of difficult navigation, and that the lakes were subject to violent and sudden storms; but how such natural obstacles could be overcome was evident, not only from the fact of General Gordon's success in the north, but from the fact that the little *Ilala* had penetrated by this waterway to the distance of nearly 1,000 miles. Mr. Cotterill then described the route by water, commencing on the Zambesi and Shire rivers; dwelt upon the delights of the region of the lake Nyassa, and spoke of the sport he had with rod and line on the lake. The lecturer thought that the more northerly parts of the lake were far more beautiful and more populous than the granite country of the south.

Ivory was stated to be in abundance, as well as the teeth of the hippopotamus. There was evidence of the presence of precious metals. Cotton grew wild, and was also cultivated by the natives. Sugar cane, grains of various kinds, yams, bananas, and the like grew luxuriantly. Indigo and coffee would probably thrive. The timber was fine, especially towards the north. The exploration of the other parts of the lake Nyassa was described by means of a large map. Mr. Cotterill stated that by the munificence of one or two private persons a direct road had already been begun of about 300 miles to

the north of Nyassa, and he contended that there were great facilities for establishing, by the aid of the waterway, a settlement in the heart of Africa, with the advantage of a line of communication. Such a settlement would command all the country to the west of the Nyassa, all the ivory wealth of the Uwvisa land, and the south region of Tanganyika, now diverted by the very circuitous routes through Ujiji to the north, or Kota Kota and Kilwa in the south. In answer to questions, the lecturer said that the lake region, when once a person became acclimatised, was as healthy as India. The marsh lands he described as exceedingly unhealthy.

New Guinea.—Mr. Ingham, who represents the Queensland Government at Port Moresby, furnishes some interesting information concerning New Guinea. Port Moresby is situated about latitude 9° 20′ S., and longitude 147° 30′ E., and access to the port is obtained through the Basilisk, opening in the New Guinea Barrier Reef, which is about five miles from the entrance of the harbour, and good anchorage is obtainable under the south head in some six fathoms of water, at a distance of a mile and a quarter from the shore. Deep water is found close up to the eastern head, from which a native track runs round the harbour to the village of Anuapata, and the colonist party in landing their horses availed themselves of this portion of the harbour, the vessel being warped to within 100 yards of the beach, whence they were able to swim the horses ashore and drive them round the village. A range of high mountains forms the backbone of the peninsula, and between these and the Port Moresby coast is first a stretch of level country and then a series of low hills, which at some places run down steeply to the sea, and at others are succeeded by a considerable stretch of comparatively level ground. These hills skirt the harbour from the eastern head to Anuapata, where they lie back from the beach sufficiently far to give abundant room for a township. Opposite to Anuapata a range of hills, dividing the harbour from the sea, forms an effectual barrier against the north-west monsoons, and renders Port Moresby absolutely land-locked. Water has to be brought from two springs at the foot of the hill, about a mile from the village. A European settlement would have to depend upon storage for its water supply.

The natives of Anuapata and the adjacent villages closely resemble the Polynesians of the New Hebrides group, especially those from the island of Motu, and, strange to say, these people call themselves Motu. This gives colour to the supposition that the Port Moresby natives were originally drifted from this island, and there can be little doubt that they are interlopers at New Guinea. Their colour is a light bronze, and their hair varies in different individuals from curly and bushy to light wavy. The total number of Motu natives in Port Moresby is about 1,000.

The available products of the country for commercial purposes

are the sago palm, the sugar cane, small quantities of cocoanuts, native flax, and cedar. Cocoanuts would not form a staple article of export, as the dense population of the country is sufficient to consume almost the whole of the present crops. There are several distinct varieties of sugar cane, all of them perfectly free from disease. Mr. Ingham states that some canes were shown him as the product of a village east of Port Moresby, which were much superior to anything he has seen in Queensland, although he has had three years' experience there as a planter. He believes that, with care and perseverance, the natives might be got to work on sugar plantations, and an unlimited supply of labour could be opened up as soon as friendly communications were established between the white men and the natives. Among the natural productions of the country may be mentioned tobacco, which is grown by the mountaineers, but their practice of drying it in the sun effectually destroys all flavour.

Of course, at present, all business between the whites and natives is carried on by a system of barter, and for this purpose Barrett's twist is found to be a most convenient article of exchange, the native consumption being such as to prevent anything like a glut in the market for some time to come—a commercial disaster which has already put a stop to the use of beads as current coin. Of course, as stocks get larger, the price of tobacco will also fall, and this has already *begun to* operate. At present, a "hodu" full of water—about a bucket and a half—is brought a distance of about a mile by the women for an inch and a half of twist, whereas the charge for the same service at the time of Mr. Ingham's first arrival was but half an inch. A cocoanut costs about an inch of tobacco; yams vary in price according to the season; a stick of sugar cane (12 ft. long) is worth about an inch and a half.

The road from Port Moresby inland is over the low range of hills at the back of the town, through a gap, at a level of 560 ft. above the sea; thence by a gentle descent into a large black soil plain, which extends for about 12 miles to the bank of the Laloki river. A large portion of this plain is covered with good kangaroo grass, and is admirably adapted for grazing cattle; on the other side of the river there are about four miles of level country, after which a dense scrub is reached, and then the lower spurs of the main dividing range. The Laloki river takes a course almost parallel to the coast, running between the main range and the east hills, and empties itself into Redscar Bay, about 40 miles from Port Moresby. The natives say that about 40 miles inland from Port Moresby, at a height of 2,000 ft. above the sea, it is only five sleeps to the big water on the other side, so that, should it ever be required, there is little doubt that communication could be obtained with the north-coast through the great gap between Owen Stanley on the west and Mount Obree on the east. The absence of ports on the north-west coast renders it not unlikely

that a large portion of it may have to depend upon Port Moresby for supplies. A third and a distinct race, called Coiairies, inhabit the large mountain ranges further inland. These men are very superior to either the Koitappos or the coast natives, both in physique and in intelligence. Westward from Port Moresby are innumerable little villages of from 200 to 400 inhabitants, and these extend along the coast as far as Cape Suckling. After passing this point a different race of people is approached; these are the true jet-black Papuans. Eastward from Port Moresby also are numerous small villages until Hood Lagoon is reached, where there is a village of 1,000 inhabitants or more. These natives are in a higher state of civilization than those of Port Moresby, though undoubtedly of the same race; they are exceedingly light-coloured, and have quite long wavy hair of a light brown colour, probably kept so by the use of lime. Beyond Hood Lagoon the villages are more populous, and in Keppel Bay there is a village of about 4,000 inhabitants.

Still further eastward the region of cannibalism is reached. One of the principal occupations of the cannibals is that of patrolling the coast in large war canoes in search of smaller craft, and woe to the canoe overhauled by them; for whether its occupants be a crew of fishermen blown out of their reckoning, or a company of traders who have ventured beyond prudent limits, their lives are forfeit to the enemy, their bodies are eaten, and their skulls taken to adorn the canoes or houses of the captors; the jawbone of the prisoner being used as an arm-ornament. The cannibals are nearly black, thereby affording additional proof that the Motu men are merely immigrants who have settled upon a small portion of the coast.

The Island of Cyprus.—A paper on Cyprus was read at the Dublin meeting of the British Association by Major Wilson, director of the Ordnance Survey of Ireland. He stated that Cyprus, the third largest island in the Mediterranean, is situated in the easternmost part of the sea, having Asia Minor to the north and Syria to the east. Cape Cormachiti is about 46 miles from Cape Anamour, in Cilicia; and Cape St. Andrea, the N.E. point, is about 60 miles from Latakia, in Syria. Since it became subject to the blighting influence of Moslem rule each year has seen vineyards run to waste, cultivation decrease, and a hopeless state of despondency settle down on the people, until at last the most beautiful and fertile of islands has become in parts almost a desert. For years the land has lain fallow; but with the influx of British capital and energy the island is capable of again becoming the garden and granary of the East. A very short time will see the great plain again covered with golden corn; but to replace the vineyards, the olive groves, and the forests which were once the glory of Cyprus will require time.

The island is chiefly occupied by two mountain ranges, having a general E. and W. direction. Major Wilson mentioned that there are three separate peaks, the highest being about 6,160 feet. There are

no vines on the summits, which are quite bare, the rock being broken up by the action of the weather. A short distance down the mountain is the large monastery of Troodissa. The level ground is covered with gardens and fruit trees, the valleys are green with pasture land, while along the coast line one village follows another in quick succession. It is the richest part of the island, and the fresh sea breezes from the north and the numberless rapid streams from the mountains make it the healthiest. There are no good natural harbours. The chief places of trade at present are only open roadsteads. Salamis and Famagousta are artificial harbours ; the latter could easily be made a good one. Tyrinia, on the north coast, is a very small and bad port, but the only one on that side of the island. Larnaca, which is built on the site of ancient Citium, is now the chief place of trade, and contains 5,000 or 6,000 inhabitants. Simosaki is the principal export town for wine. Paphos, the residence of Sergius Paulus, is where Elymas was struck with blindness. It is celebrated for the worship of Aphrodite, or Venus, who was believed to have there risen from the sea. Salamis was called by the Greeks a good harbour ; Jews had synagogues there.

The population of the island is about 144,000, of whom 44,000 are Moslems. The Cypriots are dull and stupid, but are very docile and sober, and their love of home and family is a most favourable trait in their character. The Cyprian peasants themselves have so little skill and forethought that the most careful government would have some trouble in getting them to work harder and more intelligently. "Cyprian ox" was the term of old used to describe this race, so stubborn, so wanting in intelligence; and even at the present day the true Cypriot squats in his native village, surrounded by filth, sticks to his ancient habits, and goes no further then he can help. The climate has been affected by many causes. The forests, which had been the glory of the island, have disappeared. During the period of the Turkish rule everyone cut down what he wanted; no one ever thought of replanting. The poorer the people became the more the forests disappeared, and the finishing touch was given by Mehemet Ali, who cut down nearly every tree, partly for sale, partly for shipbuilding, partly for use in Egypt. When the people were asked about disforesting they said, "It has always been done in our country;" and when the consequences were pointed out they said, "The Government wishes it," so accustomed were they to abuse the Turks for their own shortcomings.

The climate is good, but there are fevers just such as attack visitors at Malta, which last only two or three days. Near the end of the great plain there are large swamps, into which the rivers divide themselves, and are thus prevented from reaching the sea. Major Wilson recommended the introduction of the eucalyptus, or Australian gum tree, a plant which has the effect in swampy districts of producing beneficial results, as was instanced in Algeria. It is the only green plant which, after it

has grown for one year, the locusts do not attack, because of its astringent properties. This is also the more important, because the island is visited by a plague of locusts. There are also seasons of great drought, but the heavy dews to a great extent counteract their effect.

As to the mineral products, Major Wilson mentioned that copper mines had been extensively worked in the island by the Romans. The principal ones were situated near Tamassus, about three hours' ride from Dale (Idalium). Coal, or shale, has also been found near the ancient Soloe. Besides copper, Strabo mentioned that the island produced silver; and Pliny records the existence of precious stones, probably rock crystal. In saying that light fevers attacked those who visited the island he did not wish to convey that the climate was what could be fairly described as unhealthy. It arose from the circumstances which he described, which prevented the rivers reaching the sea. It would also occur to them that the place could scarcely have been unhealthy when the Greeks adopted it for the worship of Venus. He hoped that they would not be led by the acquisition of Cyprus into a military government. There was no occasion in Cyprus for the employment of a large number of troops. The number employed by the Turks was exceedingly small, and did not exceed half a regiment; and most of the soldiers used were a sort of militia, raised in the island, who never went beyond its limits.

He hoped that one of the first things the Government would do would be to send over a properly organized scientific expedition to survey the island. They had no proper topographical survey. The maps they had were by different itinerants, who had crossed the island from different directions. They had no scientific maps of the mines; and he thought a geological survey should also be made. The whole country required to be excavated, for there must be a great number of valuable inscriptions there. As an instance of what might be discovered, he mentioned the bi-lingual inscription, in Phœnician and Cypriote, upon marble found by Mr. Lane at Dale, the ancient Idalium, in the British Museum. He had no doubt that the energetic High Commissioner, Sir Garnet Wolseley, would so deal with the administration of the country that in a few years Cyprus would set an example to the whole country of rich produce. He would like to see the old Castle of Buffamento one day the seat of the High Commissioner of the island of Cyprus.

The Land of Midian and its Mines.—An expedition into the Land of Midian was undertaken by Captain Burton in the close of 1877. The object of the expedition was to examine into the mineral wealth of the country, which hitherto has been very little visited by travellers, and is only imperfectly know to geographers. Yet the minerals of Midian were known both in biblical and clasical times. Everybody remembers how Moses, when he fled from the face of Pharaoh, dwelt in the land of Midian and married the priest's

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daughter; and how, notwithstanding this alliance, the children of Israel, after the Exodus, vexed by the wiles of the Midianites, made war upon them and slew their kings, and burnt their cities and their goodly castles, and spoiled them of "gold, silver, brass, iron tin, and lead," and "jewels of gold, chains and bracelets, rings, earrings, and tablets;" and how Moses ordered the wrought jewels of gold to be brought into the Tabernacle as a memorial. It is equally well-known, too, how the Romans long afterwards again worked the mines whence these metals were dug, and many are the traces of their work which Captain Burton has recently found. Yet next to nothing is now known of the country, its wild wastes of rock, its barren valleys and precipitous mountains, its vast half-worked mines, its ruined cities, and its wandering and savage population. That it lies to the east of the Red Sea, that it belongs, for some mysterious reason, to Egypt, is about all 99 out of every 100 people know about it.

Captain Burton's expedition left Suez on December 10, 1877, and returned there on April 20, 1878. During four month of hard travelling and voyaging, upwards of 2,500 miles, they only lost one soldier, who died of fever. They brought home some 25 tons of geological specimens to illustrate the general geological formation of the land; six cases of Coloradò and Negro ore; five cases of ethnological and anthropological collections—such as Midianite coins, inscriptions in Nabathean and Cufic, remains of worked stones, fragments of smelted metals, glass and pottery; upwards of 200 sketches in oil and water colours, photographs of the chief ruins, including catacombs, and of a classical temple, apparently of Greek art; and, finally, maps and plans of the whole country, including 32 ruined cities, some of whose names can be restored by consulting Strabo and Ptolemy, besides sketches of many *ateliers* where perambulating bands like the Gipsies of ancient and modern times seem to have carried on simple mining operations.

Among the specimens are argentiferous and cupriferous ores from Northern Midian, and auriferous rocks from Southern. There are collections from three turquoise mines, the northern, near Aynuneh, already worked; the southern, near Ziba, still scratched by the Arabs; and the central, until now unknown save to the Bedouins. There are, moreover, three great sulphur beds, the northern and the southern, belonging to the secondary formation (now invaded by the trap granite), and the central, near the port of Mowilah, of pyretic origin. Rock salt accompanies the brimstone, and there are two large natural salt lakes. The whole of the secondary formation supplies fine gypsum, and in parts of it are quarries of alabaster, which served to build the ruins of Maghair, Sheéayb, Madiama (of Ptolemy), and el-Hauré (Leuke Kome), the southernmost part of western Nabathea.

The term Midian, popularly derived from Medan, the Hebrew, is really the Old-Egyptian "Mádi," a word which occurs in many

papyri, whose plural is Mádian, or Mádiná. The modern tribes that hold the land confine "Mádyan" to the strip of maritime country between the coast of Ghauts and the sea, from the fort of Allabah (lat. 29° 30′) to Mowilah (lat. 27° 32′). Captain Burton calls this country Northern Midian, and he applies the term Southern Midian to the tract of about similar size stretching south from Mowilah to the great Wady Hamz (lat. 25° 55′ 15″), where Egypt ends, and the Hedjaz—the Holy Land of the Moslems, the capitals of which are Mecca and Medina—begins. He also divides the country into two mineral districts: the northern, with Makná as its port, has not been much worked; the southern, with Wedj as its harbour, shows extensive traces of ancient scientific labour. But he describes the whole as affording great mining capabilities to modern science. These conclusions he arrived at by dividing his four months' exploration into three several excursions—northern, central, and southern.

The caravan consisted of eight Europeans, three Egyptian officers of the staff and two of the line, 25 soldiers and 30 miners, 10 mules, and about 100 camels. The northern excursion commenced at Mowilah, the port of arrival in Midian. They revisited the country covered by Captain Burton's expedition in 1877. After re-inspection of the ancient working of the precious metals, passing the traditional site of Moses' Well, they marched upon Makná, the port, and spent a week digging into and extracting the veins of silver which thread the quartz, carelessly cupeled specimens, yielding 15 to 20 per cent. of silver. The hill is within a few minutes' walk of the coast, and by means of Mr. Haddan's cheap tramways it would be easy to ship the ore in the harbour. Leaving Makná, they rounded the windy Gulf of Allabah; and the incorrectness of the British hydrographic chart very nearly shipwrecked the party on the reefs off the island Tiran. They reached Mowilah again on February the third.

The second expedition followed and was directed to the inland region east of Mowilah. The object was to determine the longitudinal breadth of the metalliferous country. A double chain of ghauts subtends the coast, and a succession of valleys cut through these heights. Beyond the ghauts a rough and precipitous pass, terrible for loaded camels, leads to the Hisma, a plateau some 4,000 feet high, of new red sandstone, which is in reality the western wall of the Nejd, or great central uplands of the Arabian peninsula, and is remarkable for the beauty of its brick-red precipices and castellations. East of the Hisma lie the dark lines of the Marreh, the basaltic, and doubtless volcanic regions whence the miners of old brought the rough mill-stones that served for their first grindings. But here the expedition reckoned without its hosts, the Maazeh, a semi-Egyptian tribe, who received them apparently with friendliness, but all the while were preparing for attack, murder, and plunder. The trap, however, was badly set for an old traveller,

Captain Burton guessed the coming danger, and was able to beat a hasty retreat without bloodshed. The expedition, altering its plans, then turned to the south-east. They passed through the lovely Wady Daumah, once teeming with fertility, now laid waste by the Bedouin, "the fathers of the Desert." They discovered the ruins of the city of Sheewak (the Souka of Ptolemy), which, with its outlying suburbs, its aqueducts carefully built with cement, its barrages across the village heads, its broken catacombs, its furnaces and vast *usines*, covers some four miles. Here and elsewhere the furnaces were carefully searched. The Colorado quartz-ore and the chloritic greenstone, used as flur, showed what ore had been treated; but so painstaking were these old miners that not the minutest trace of metal was left to tell its own tale. Sheewak was evidently a city of workmen, probably of slave workmen. A few miles to the south lay Shaghab, the ruins of which, far superior in site and construction, suggested the residence of the wealthy mine-owners. Here the expedition turned west. The country was barren, roadless, and very thinly inhabited, but they came upon the ruinous traces of mining operations at every stage. On March 5 they arrived at the flourishing little port of Ziba (Zibber on the hydrographic chart), built with the remnants of some older town. Near Ziba was found the southernmost of the turquoise mines. Its natives have learnt the art of promoting the growth of pearls by inserting a grain of sand into *each oyster.*

The third, or southern excursion, which Captain Burton was enabled to undertake by the despatch of a second ship and another month's food from Suez, proved by far the most interesting to mineralogist and archæologist alike. Gold mining evidently here takes the place of silver and copper extracting, and the vast traces of the labours of the scientific old miners in shafting and tunnelling teach exactly their *modus operandi.* The Marreh, or volcanic district, which they inspected, extends as far as Yembo, and possibly as far as Medina, the Holy City. It is covered with ruins of mining works, and the expedition found gold threading and filming the basalt, which led them to believe this district to be the focus of the mineralogical outcrop. Meanwhile, M. Marie, the mining engineer, proceeded to the southern depot of sulphur, and discovered a third hill distant only two miles from a navigable bay. He secured specimens of this rock and also of chalcedony, the material of the finely-engraved seals and amulets worked by the natives. He found, and the whole party afterwards visited, an outcrop of quartz, in mounds, hillocks, and gigantic reefs, called "Abel Marwah," and the disused works, of great extent, were surveyed.

The caravan, now guided by the Balizy tribe, which claims some of the old mining districts, left the port of Wedj, March 23, and visited the ruins of Um el Karayyat ("Mother of Villages"), where the remains of mining operations lie scattered about in all directions. In parts the hill of snowy quartz has been so well burrowed

into that it has fallen in. All the shafts and passages were duly explored. The precious metal was extracted from the rose-coloured schist veining the quartz and specimens of free gold appeared. The next march showed the Um el Kharab ("Mother of Desolation"), in which an extensive vein had been worked, and pillars of quartz left standing between roof and floor. Travelling through a land once rich and prosperous as mining could make it, now the very picture of dreary desolation, the travellers reached the plain El Beda (Bedais of Ptolemy). Here the hills of red porphyry were covered with religious inscriptions in the Cufic and modern Arab characters; nothing Nabathean occurred. On April 8, after traversing another quartz country, the expedition reached their Ultima Thule, the Wady Hamz, the great gap worked by water in the maritime mountain chain which forms the highway for pilgrims returning from Medina, and constitutes the frontier between Egypt and the Hedjaz, which belongs to Turkey. Here a pleasant surprise awaited the party. On the southern brink of this wild water course was the site of a beautiful little temple, built of white and variegated alabaster, dug from neighbouring quarries. The foundations alone were left, and a few years ago the place was a tumulus into which the Arabs dug for treasure. The Wady had washed away the northern wall, and the adjacent bed was strewn with fragments of columns, bases, and capitals, all of alabaster and cut in the simplest and purest style of Greek art. Can this be a vestige of that ill-fated expedition in which Ælius Gallus was foiled by the traitor Nabathæsus?

This closed the expedition. The party returned to Suez, and arrived in Cairo the 21st of April. They received a most courteous welcome from his Highness the Khedive. So ends the story. After all allowances made for the traveller's love of the scene of his labours, it must be admitted that the Land of Midian is a wonderful place. As one hears of the mines that are spread over the country, with their shafts and their tunnels, their furnaces and their barrages, the towns of workmen, and the cities of mine owners, one begins to understand why "all King Solomon's drinking vessels were of gold, none were of silver, it was nothing accounted of in the days of Solomon."—*Times.*

More about the Land of Midian.—Captain Burton read a paper on Midian at the Dublin Meeting of the British Association. All who read their Bible, he remarked, are familiar with such phrases as "vexing the Midianites" and "Midianitish women," but they did not know how hazy on the subject of this grand old land the public of England was before the spring of 1877. About 1249 B.C. the Midianites regained their former power; but after the crushing blow they subsequently sustained, they fade out of Holy Writ, and their land becomes almost unknown. Josephus's mappers recognized two Midians, whereas there has never been more than one. Voltaire, the noble Frenchman who created religious liberty in France, made a mistake about

Midian, placing it on the eastern half of the Dead Sea, and considering it a little canton of Idumæa, about eight leagues long.

Captain Burton described the exact limits of the country, and then proceeded to narrate his expeditions and discoveries. Both expeditions which he had the honour to lead were sent out by the Khedive of Egypt, a prince to whom the future will be more just than the present is, and to whom we are indebted for our present knowledge of a neglected and most mythical country. In 1877 the Khedive placed under his command the first expedition. This preliminary visit lasted little more than a fortnight, but it gave him a fair general view of the country, and he brought back specimens of most of the metals mentioned in the Book of Numbers. About the beginning of 1878, he returned to Cairo, and organized a second expedition on a larger scale. They first explored Northern Midian and discovered a number of catacombs and many inscriptions very deeply cut, but not easy to decipher. One cutting he found was like St. George and the Dragon, but St. George was without his horse. Photographs of the catacombs and inscriptions were exhibited by Captain Burton. On the Gulf of Akabah the expedition was nearly wrecked, the wretched boiler of their steamer having struck work, and they were only saved by the exertions of their Scotch engineer, David Dougall, who managed to start the engine again when they were drifting rapidly on to a reef of sharp rocks and were just 50 yards off. But after this the Khedive was good enough to supply them with a better ship. Their explorations in the interior were at one place interrupted by the hostility of the tribes, who would not permit the expedition to enter their territory without paying a fine equal to £100 each per diem. On the 25th of February therefore, they were obliged to retrace their footsteps.

Proceeding in another direction, they found old smelting furnaces and caves, which might have been catacombs, and a great aqueduct. They were astonished by traces of immense labour, which yielded not a single line of inscription, nor even a mason's mark, to determine the race of the labourers. He was able to identify some of the places with those mentioned by Ptolemy. Turquoise was a favourite gem among the Bedouins, and judging from a large one he had seen inserted in the stock of a matchlock, which had probably been there for 50 years, it was not liable to change colour.

The exploration of South Midian was the most interesting. Photographs were taken of old mining works, and in some of the minerals they found silver visible to the naked eye. Pathetic indeed is the view of the desolation of Midian. Once the Arabia Felix of the ancients, it has now become Arabia Petræa, Arabia Deserta. Under Roman rule it contained 20,000,000 of souls. Now the population was reduced to 2,000,000, but the Anglo-Turkish Convention puts England nearly in the same position as that occupied by Rome after the days of Augustus. He had full and perfect faith that Midian, like

many other provinces, would presently awake from her trance—from her sleep of ages. Midian contained a mining region 300 miles in length, and of equal depth, and he had but little doubt that what the ancients worked so well we moderns could work better still; so that Midian might look forward to the development of her mineral wealth under the fostering care of European and especially of English companies, and the howling wilderness become turned into a rich and fruitful land.

Opening of the East African Lake District.—A paper on the opening up of the East African Lake District was read at the Dublin meeting of the British Association, by Mr. J. Stevenson. He stated that the object most prominently in view in founding settlements in the interior of Eastern Central Africa was the Christian civilization of the natives. The Nyassa region had the advantage of being accessible by the only considerable rivers of Eastern Africa, and the attempts of Livingstone to place steam vessels on these rivers had shown there was no insuperable obstacles in the way. On the other hand the policy which had hitherto characterised the Government of the Portuguese colonies, rendered it very doubtful whether any advantage could be derived from the existence of these rivers in opening up the country. Trusting that the Portugese would see that the opening up of the country would be of real advantage, we decided to place our settlement behind their provinces. The immediate results were discouraging, for a hostile tariff was issued, and the exclusive right of steam navigation on the rivers Zambesi and Shire was offered to a Portuguese subject; the concession being for 30 years. The feeling which dictated this exclusiveness seems to have gradually passed away.

The slave trade under treaty obligations terminated in 1877, and domestic slavery was abolished two years before. The feeling was that the honour of the country should not be responsible for what happened in regions where it had no real control. The proposal of our Minister at Lisbon—that a vessel should be placed upon the station—met the approval of the Portuguese authorities, and the vessel was sent out to Quilimane, under the charge of Messrs. Moir, of Edinburgh, who were to conduct navigation and trade for an independent company that has recently been formed in Glasgow, called the "Livingstonia Central African Company (Limited)." The object in view is rather co-operation in the civilization of the country than money-making.

The navigation between the River Zambesi and Lake Nyassa is interrupted by rapids extending 60 miles along the Shire from the upper end of the rapids. The steamer Ilala takes the traffic on to Livingstonia. The tribes to which a future is thus opened belong to the Caffre and not to the Negro family of race. Towards the middle of the lake, on the west side, the old inhabitants have greatly felt the pressure of the Mavitti, or Mazitu. These were originally an army of warriors of pure Zulu race, who issued from

Moselekatse's country 50 years ago. They kill the men of the tribes they conquer, and take the women and children for themselves. While retaining the Zulu language and their weapons—the shield of bull's hide and spear—they are much mixed, and have not the desperate courage of the pure Zulu stock.

The settlement of Livingstonia was planted among the races who are still under Arab influence at the south end of the lake. During 1877 a detachment of the Livingstonia staff assisted in founding the new settlement, called Blantyre, at the request of the head of the Scottish Established Church Mission. Last year Dr. Stewart, of Lovedale, and Dr. Laws, of Livingstonia, commenced intercourse with the natives of this northern region, especially at the embouchure of the Kambwee and of the Rombashi. The excitement at the first appearance of white men, dropping so suddenly upon them, was very great. Following Livingstone's plan, they thought it better to pave the way for future visits than push on while the people were in this state.

With the co-operation of the natives a good route might be established through the valley which leads to it, and by a third steamer placed upon the lake easy communication might be opened up to a distance of 2,000 miles from the coast, and a near approach made to the centre of the habitable regions of Africa. It is stated that on the other side of the lake a gorge or pass, apparently separating the Livingstone and Knode Mountains, *stretches* in a south-easterly direction, which may prove the most convenient line for reaching the coast about Kilwa or Lindy. It is also stated that thereabouts the country is inhabited by the Gangvarar, a warlike race, who are said to be workers in iron.

For some time they had been favoured with the presence of Captain Elton, Her Majesty's Consul at Mozambique, and finding that he was desirous of making an overland journey from the head of the lake, they gave him, with some friends and natives, about 200 in all, a free passage by the steamer, and landed them at the Rombashi, the nearest point to Merces. They heard no more of them till natives who had accompanied them returned to Livingstonia. Mr. Stewart, C.E., then writes as follows:—"Pangasina, and one of Cotterill's men have returned. Our worst fears of Elton's expedition have been realized. Captain Elton himself has fallen a victim. The narrative we have from Pangasina shows them to have had a terrible journey. Five days' march from where they left you they were in difficulties. Captain E., Mr. C., and Mr. Downie went forward to provide carriers, and at the village they went to they were attacked by Marvin. The attack was intended for a village belonging to a chief named Meree, and not directly on the English. In the circumstances Elton was forced to fight. The attack lasted four days. You may imagine the slaughter three excellent shots with breechloaders would accomplish in that time—somewhere between 40 and 100 I should estimate, from the account. On

the fourth day Elton shot the attacking chief, and the assailants retired." As we have learned, the party were in difficulties about their carriers the very first day after they started. Most of them deserted with five days' pay, and the head men were put in confinement to prevent the others leaving. On the second and third day the natives, in reprisal, attempted to inveigle some of the steamer's people, and on the fourth became so hostile that the steamer left for Kambwe, no harm being done. But the fight with the Mavitti, if Mavitti they were, may be a serious matter, for according to Stanley they have spread themselves over the country nearly to Lake Victoria, to the country where the Church and London Missionary Societies have, or are about to have stations, and they extend all along by Tanganyika and the west side of Nyassa. Mr. Stevenson thought that such plunges among wild and unknown tribes should not be made. The population of Great Britain had supplied nearly £50,000 through the above-named societies and the Scottish Churches, in order to introduce Christian civilization into the region of the lakes, which is as large as India. The difficulties were very great, but there was reasonable prospect of success.

African Exploration by Mr. Stanley.—Mr. Henry M. Stanley delivered an address on the subject of his recent achievements in Africa, at a special meeting of the Royal Geographical Society, on the evening of the 7th Feb., 1878. He said that Zanzibar as they all knew, was his starting point. On arriving there he sent his emissaries through the streets of the town to hunt up followers, and it was soon known that the "open-handed white man," as he was called, was again on the island. Fifty or 60 men soon came to him and asked what he proposed to do. He said he meant to cross the continent, though he should have to cross mountains and lakes, to make his way through wastes and forests, and have to face strange and savage tribes and races and nations. They said it would take years to do so—that they could never hope to see their families or native land again; but when he reasoned with them, they asked him how much he would give them. He said he would give them three dollars a month, and from 150 to 200 eventually signed articles for that sum. After a time, however, they returned and demanded five dollars a month, saying that the last explorer had given that sum, and he was obliged to comply.

Well, the day of starting at length came, and they landed on the East Coast of Africa, which had been so thoroughly described by Livingstone, Grant, Speke, Cameron, himself, and others, that he need not say more about it or of his route until he broke off from his former track and headed for Lake Victoria. Before reaching the lake, he made the acquaintance of a tall, swarthy prince, whose perfectly natural manner and friendly tone were such as to win their way to the heart. He had then, he said, for the first time seen a white man. From the district governed by that prince he made his way to the country of

the Masaai, who, it was said, delighted in the drinking of blood. They were a warlike people, and from what he saw of them he could say that if any one wished to be murdered there was no people on the earth who would be more likely to gratify that desire than those he spoke of. The people of Soona were equally savage and more suspicious. He endeavoured to conciliate them by making them presents of old tin pots and exhausted sardine boxes; but, finding that, notwithstanding this, one of his men was killed and another badly wounded, he thought it wise to move on, but could only do so successfully after three days' skirmishing.

Soon afterwards he reached the region over which M'tesa ruled—Nganda. In him he found a good and kind man, and before he left M'tesa not only observed the Islam, but also the Christian Sabbath, and he also had the Ten Commandments, the Lord's Prayer, and the Golden Commandment of our Saviour, "Thou shalt love thy neighbour as thyself," cut upon wood that he might contemplate them daily. Here he found a great harvest for the sickle of civilization and Christianity. The missionary that was required must be a practical man. He should, of course, be a teacher of Christianity; but to be truly successful he must be able also to give instruction in the construction of dwellings, in the cure of diseases, in agriculture, and be something too of a sailor. Such was the man that was wanted for the work; a band of such men would be the salvation of Africa. But, again, *he must* be tied to no Church or sect, he must love God and his Son, and teach the moral laws, and be in charity with all men, belonging to no nation in particular, but to the entire white race, exhibiting practically the interest taken by them in the welfare of the black.

It had been said that the African was unimprovable and irredeemable; but that he wholly and utterly denied. Well, having reached Lake Victoria, and going to the Albert, he became acquainted with another ruler named Ruminika, who was also a natural born gentleman. He found it, however, a more difficult thing to make a Christian of him than of M'tesa, but a very pleasant month he spent in the district of that Prince. They next came to Ujiji, which had been spoken of as the watering-place of explorers. He could not, however, enjoy it long, as he had to follow up the work his predecessors had left undone.

The lecturer then proceeded to speak of the river Lualaba, which Livingstone had mistaken for the Nile, and of his successful voyage—one which was beset with all but insurmountable difficulties—down the Congo. To reach it they had to make their way day after day through dense forests. The stories as to the ferocity of the natives of the towns and villages on the banks of the river terrified his men, and more than once he feared he would find himself deserted, and that the work he had set himself to do would remain unaccomplished. At length, however, the voyage was commenced. To pass the first falls they had to work night and day for 26 days, during which they cut 13

miles of road through forest, along which they carried their canoes. They were subject to constant attacks from natives. On one occasion no fewer than 63 war canoes came against them—the leading canoe being driven by 80 paddles—and each was filled with armed savages. He told his men that if they desired to see home again they must resist to the last, as they could hope for no mercy; but he ordered them not to fire till they were assailed, as they must first see what the natives came for. The order was strictly obeyed. It was not till poisoned arrows were shot at them and spears flung that they fired, and then the rattle of 52 muskets was heard in a country in which never musket had been fired before. He had done all he could to avoid fighting and only acted in self defence; for his strong desire was to be and to remain on good and friendly terms with the various tribes he met with. Day after day, however, they were attacked, and had, in consequence, to suffer great privations. They were reduced to great extremities—almost to starvation—when happily they approached Boma. To that town he sent four men with a letter directed to any English resident, stating that 115 souls were in a fearful condition from want of food. Happily, the only agent from an English house in Boma got the letter, and he and the other merchants of the town sent them large supplies of biscuits and bread, and fish and rum, and tobacco. It was the relief of Lucknow over again. Thus was the work completed which he had set before him. In due time they reached the Cape, where one of Her Majesty's ships was placed at his service. He conducted his men back to Zanzibar, and as they touched the strand of their island they kissed the sand, and uttered the words, "La Allah il Allah!" ("Thanks be to God").

V.—GEOLOGICAL RECORDS.

Earth-Temperatures and their Increase with Depth—The boring of the St. Gotthardt Tunnel has yielded some very valuable results on earth-temperature, which have been laid before the Swiss Naturforschende Versammlung by Herr Stapff, and are discussed by Dr. Hann in the *Austrian Journal* for January 15, 1878. If the observations be considered with reference to their vertical depth, we have a mean rise of 1° C. for 46 mètres; but this varies very seriously in different parts. Thus, under Andermatt we find a rise of 1° C. for 21·8 mètres. This would give a temperature of 77° C. for the centre of the tunnel. This exceptional result Herr Stapff attributes to the state of decomposition of the rock at the place, which is a granite turning into kaolin. Dr. Hann discusses these observations with great care, and points out the difference between these results and those of the bore-hole of Sperenberg, which are generally thought the most accurate in existence, and give as result 1° C. for 33·7 mètres. The paper concludes with a serious warning to physical geographers to the effect that there seems little prospect of learning anything of the true rate of internal increment of heat by these observations. We have only attained a depth of 1,269 mètres, or about $\frac{1}{10000}$ of the earth's diameter. If we were to attempt *to determine* in the same way the law of diminution of temperature with height in the atmosphere, a similar proportion to the height of the atmosphere (60 miles) would be 22·16 mètres, the height of an ordinary house. Hence our deepest bore-holes are mere scratches, and we really know nothing certain on the subject.

The Geology of the Polar Regions.—At a meeting of the Geological Society, in the spring of 1878, a paper was communicated by Captain H. W. Feilden, R.A., F.G.S., and Mr. De Rancé, Her Majesty's Geological Survey, on the geological results of the Polar Expedition under Admiral Sir G. Nares, F.R.S. The authors describe the Laurentian gneiss that occupies so large a tract in Canada as extending into the Polar area, and alike underlying the older Palæozoic rocks of the Parry Archipelago, the cretaceous and Tertiary plant-bearing beds of Disco Island, and the oolites and lias of East Greenland and Spitzbergen. Newer than the Laurentian, but older than the fossiliferous rocks of Upper Silurian age, are the Cape Rawson beds, forming the coast line between Scoresby Bay and Cape Cresswell, in lat. 82° 40′; these strata are unfossiliferous slates and grit dipping at very high angles. From the fact that Sir John Richardson found these ancient rocks in the Hudson Bay territory to be directly overlaid

by limestones, containing corals of the Upper Silurian Niagara and Onondaga group, Sir Roderick Murchison inferred that the Polar area was dry land during the whole of the interval of time occupied by the deposition of strata elsewhere between the Laurentian and the Upper Silurian; and the examinations by Mr. Slater, Dr. Haughton, and others of the specimens brought from the Parry Islands have hitherto been considered to support this view. The specimens of rocks and fossils, more than 2,000 in number, brought by the late expedition from Grinnel and Hall Lands, have made known to us, with an absolute degree of certainty, the occurrence of Lower Silurian species in rocks underlying the Upper Silurian, and as several of these lower Silurian forms have been noted from the Arctic Archipelago, there can be little doubt that the Lower Silurians are there present also. The extensive areas of dolomite of a creamy colour discovered by M'Clintock around the magnetic pole, on the western side of Boothia, in King William's Island, and in Prince of Wales' Land, abounding in fossils, described by Dr. Haughton, probably represent the whole of the Silurian era and possibly a portion of the Devonian.

The bases of the Silurians are seen in North Somerset, and consist of finely-stratified red sandstone and slate, resting directly on the Laurentian gneiss, resembling that found at Cape Bunny and the cliffs between Whale and Wolstenholme Sounds. Above these sandstones occur ferruginous limestones with quartz grains, and still higher in the series the cream-coloured limestones come in. The Silurians occupy Prince Albert Land, the central and western portion of North Devon, and the whole of Cornwallis Island. The carboniferous limestone was discovered rising to a height of 2,000 ft. on the extreme north coast of Grinnel Land, in Fielden and Parry Peninsulas, and contains many species of fossils in common with the rocks of the same age in Spitzbergen and the Parry Archipelago, being probably continuously connected with the limestone of that area, by way of the United States range of mountains. The coal-bearing beds that underlie the carboniferous limestones of Melville Island are absent in Grinnel Land, but they are represented by true marine Devonians, established in the Polar area for the first time, through the determination of the fossils by Mr. Etheridge. In America a vast area is covered by cretaceous rocks. The lowest division, the Dakota group, contains lignite seams and numerous plant remains indicating a temperate flora; overlying the cretaceous series are various Tertiary beds, each characterised by a special flora, the oldest containing subtropical and tropical forms, as various palms of Eocene type. In the overlying Miocene beds the character of the plants indicates a more temperate climate, and many of the species occur in the Miocene beds of Disco Island, in West Greenland, and a few of them in beds associated with the 30 ft. coal seam discovered at

Lady Franklin Sound by the late expedition. The warmer Eocene flora is entirely absent in the Arctic area, but the Dakota beds are represented by the "Atane strata" of West Greenland, in which the leaves of dicotyledonous plants first appear. Beneath it, in Greenland, is an older series of cretaceous plant-bearing beds, indicating a somewhat warmer climate, resembling that experienced in Egypt and the Canary Islands at the present time. In the later Miocene beds of Greenland, Spitzbergen, and the newly discovered beds of Lady Franklin Sound, the plants belong to climatal conditions 30° warmer than at present, the most northern localities marking the coldest conditions. The common fir (Pinus abies) was discovered in the Grinnel Land Miocene, as well as the birch, poplar, and other trees, which doubtless extended across the polar area to Spitzbergen, where they also occur.

At the present time the coasts of Grinnel Land and Greenland are steadily rising from the sea, beds of glacio marine, with shells of the same species as are now living in Kennedy Channel, extending up the hillsides and valley slopes to a height of 1,000 ft., and reaching a thickness of 200 ft. to 300 ft. These deposits, which have much in common with the "boulder clays" of English geologists, are formed by the deposition of mud and sand carried down by summer torrents, and discharged into fiords and arms of the sea, covered with stone and gravel laden floes, which, melted by the heated and turbid *waters, precipitate* their freight on the mud below. As the land steadily rises these mud beds are elevated above the sea. The coast is fringed with the ice foot, forming a flat terrace 50 to 100 yards in breadth, stretching from the base of the cliffs to the sea margin. This wall of ice is not made up of frozen sea water, but of the accumulated autumn snowfall, which, drifting to the beach, is converted into ice where it meets the sea water, which splashes over it.

Eruptions and Earthquakes in the Year 1877.—Five eruptions of different volcanoes occurred during the year. The eruption of the South American volcano, Cotopaxi, lasting from 25th to 28th June, had a regular, and (for this volcano) very characteristic course. From the phenomena it is to be designated as an ashes and mud eruption. Though the opinion of Humboldt, that the South American volcanoes produce no lava, has long been shown to be erroneous, and Cotopaxi first gave a large stream of the substance in 1853, there are still large quantities of ashes thrown out by this volcano without lava. Mud streams are frequently associated therewith, and are due to various causes. They wrought great devastation, especially in the valleys of Chila and Tumbaco, and in the former several hundred men perished; the ashes spreading in the air changed the day into dense night, and even penetrated into the interior of closed rooms.

A most remarkable eruption of 1877 took place on the island of Hawaii. Twice interrupted, it found a path for itself in three different places—thereby showing

that one and the same source of eruption may, according to the time and circumstances, use any of the numerous channels present in Hawaii for outburst. The first portion of the eruption appeared for six hours on the 14th of February in a small secondary crater, near the top of the Mauna Loa, and was distinguished by the magnificent pine-like form of the column of smoke, which was estimated to rise 5,000 mètres. On the 24th of February the second act occurred in the bay of Kalukeakua, known as the scene of the murder of Captain Cook. There was also a submarine eruption lasting two days, in the middle of this bay, which is surrounded by pre-historic volcanic products. On the 4th of May, the eruption again found its ordinary outcome through the long solidified lake of lava of the Kilauea. Then appeared once more the grand spectacle of lofty fountains of lava, which has only been witnessed in this giant crater. In the space of six hours, fountains of lava sprang up, now here, now there, out of the large caldron, and so numerous were they that at one time more than fifty were observed in action at once, some of them being as high as 30 mètres.

The third eruption was that of the small Japanese island volcano, Ooshima, from 4th January to 6th or 7th February. Violent noises and dreadful earthquakes accompanied, especially the large eruption phenomena on the 20th January and 4th and 5th February.

On the 11th of June an outburst occurred in a hitherto almost unknown volcanic region in Colorado, South California, about 60 English miles from Fort Yuma. As little known is the submarine eruption which took place on the 15th of June on the coast of Peru.

The number of earthquakes in 1877, of which M. Fuchs had information, was 109; this is just about the average number obtained from his observations, extending over thirteen years. They are distributed as follows over the seasons:—Winter (Dec., Jan., Feb.), 33 earthquakes; Spring (March, April, May), 31 earthquakes; Summer (June, July, Aug.), 11 earthquakes; Autumn (Sept.,Oct.,Nov.), 34 earthquakes. On 15 days several earthquakes occurred in different places.

Certain regions, such as Peru, Bolivia, Tokio in Japan, and the island Ooshima, were visited by earthquake-periods, consisting of a large number of shocks and concussions, now weaker, now stronger, while other places were repeatedly visited by earthquakes which were separated by long periods of rests. Among the latter may be specified the following:—Western Odenwald, 2nd and 10th Jan.; Judenburg, 4th Jan., 27th and 28th Dec.; Forest in Steiermark, 12th Jan., 5th Sept.; Rattenberg in Tyrol, 8th April, 11th Oct.; Bad Füffer in Steiermark, 4th, 7th, 24th and 25th April, 12th Sept.; Callao, 22nd April, 14th May, 9th Oct.; West Switzerland, 2nd May, 8th Oct., 30th Nov.; Lisbon, 1st and 4th Nov., 22nd Dec.

The earthquakes in Switzerland had a remarkable extent; the first of them, on 2nd May, appears to have passed outwards from the

lake of Zurich, and to have reached eastwards beyond Glarus and St. Gallen, westwards as far as Mühlhausen in Alsace, northwards into the Black Forest. More violent, and still more extensive was the earthquake on 8th Oct., which was strongest in Geneva (so that *e.g.* chimneys were thrown down), and which passed from this over the cantons of Geneva, Waadt, Wallis, Neufchatel, Friburg, Berne, and Baselland.

Beyond Switzerland it was traced in the French departments of Drome, Isère, Rhone, Savoie, Ain, Jura, Doubs, and in the Belfort district, as also at Muhlhausen in Alsace. The extension westwards was thus much farther than eastwards, where the Alps seem to have arrested it, for only the flat and hilly canton districts were affected by it, and the movement penetrated only in the broad Rhone valley into the Alpine region proper, as far as Sitten. This is the more remarkable, because the Jura range offered no obstacle to the extension westwards. The greatest width of the strip of land affected between Lyons and Sitten was about 200 kilomètres, the greatest longitudinal extension from Valence to Mühlhausen 337 kilomètres. To the extensive earthquake regions of lands which have few earthquakes belongs the shock of 4th April, in the eastern Alps, which reached from lower Steiermark to the lower part of the Save.

The most violent earthquake of the period occurred on the 9th May, on the west coast of South America. Both in its course, and in the accompanying phenomena, it had a remarkable similarity to the great earthquake of 30th Aug., 1868, in the same region. The centre of the concussion lay in the desert of Alkama, where the small harbour towns of Cobija, Autofagarta, Tocapilla, and others, were almost entirely destroyed. The movement was propagated thence over the greater part of Bolivia. The concussion of the ground was followed by a motion of the sea, a so-called earthquake-wave, which wrought great devastation along the coast of South America. In Chanavaya the sea drew back at first—in all other places, the high wave (in some cases reaching 20 mètres) seems to have been first observed. This hill of water rushed over the flat coasts, and left frightful ruin in its track. In Iquique 600 men perished by the inundation. In Chanavaya the majority of the inhabitants saved themselves by flight to the higher points, but even there, through the dash of the water to the ridge of the hill, many lost their lives. The ships in the different harbours were partly driven against each other, and shattered or torn away from their anchorage, and hurled by the wave on to the sand. At Arica lay, far inland, half-buried in sand, the North American steamer, *Wateron*, which had been carried thither by the earthquake wave of 1868; the wave of 9th May, 1877, lifted her again, and carried her 2½ kilomètres further. Cobija, Mejillones, Tocapilla, Sampoca (70 miles from Iquique), and Arica are almost entirely destroyed. Huaxillos, Iquique, Mollanda, and the Chilian harbours of Chero and Carrizol suffered much. The ac-

tion of this flood extended from 12° to 32° south latitude.

The earthquake-wave was propagated over the ocean, and especially affected the Sandwich Islands, where the town and bay of Hilo, on the west coast of Hawaii, were most devastated. At first the sea drew back, and then, about an hour later, rushed far inland, as a steep hill of water, 5 m. high. The wreck of the destroyed village of Waiakea, the magazine and harbour of Hawaii, is still to be observed.

Geological Questions of Recent Date.—In opening the proceedings of the Geological Section of the British Association, the president, Dr. John Evans, delivered an interesting address. After a few general observations with regard to the geology of Ireland, he proceeded to touch briefly on some of those questions which during the preceding twelve months had occupied the attention of those engaged in geological inquiry. The first of those questions was the date which is said to be assigned to the implement-bearing beds of the palæolithic age in England. "Dr. James Geikie," said Dr. Evans, "has held that for the most part they belong to an interglacial episode towards the close of the glacial period, and regards it as certain that no palæolithic bed can be shown to belong to a more recent date than the mild era that preceded the last great submergence.

"His follower, Mr. Skertchley, records the finding of palæolithic implements in no less than three interglacial beds, each underlying boulder clays of different ages and somewhat different characters, the Hessle, the purple, and the chalky boulder clay. This raises two main questions, first, as to how far Dr. Croll's theory of the great alternations of climate during the glacial period can be safely maintained; and secondly, how far the observations as to the discovery of implements in the so-called Brandon beds underlying the chalky boulder clay can be substantiated. Another question is how far the palæolithic deposits can be divided into those of modern and ancient valleys, separated from each other by the purple boulder clay, and the later of the two older than the Hessle beds. It would be out of place here to discuss these questions at length. I will only observe, that in a considerable number of cases the gravels containing the implements can be distinctly shown to be of much later date than the chalky boulder clay, and that if the implements occur in successive beds in the same district, each separated from the other by an enormous lapse of time, during which the whole country was buried beneath incredibly large masses of invading ice, and the whole mammalian fauna was driven away, it is a very remarkable circumstance. It is not the less remarkable because this sucession of different palæolithic ages seems to be observable in one small district only, and there is as close a resemblance between the instruments of the presumably different ages as there is between those of admittedly the same date. I have always maintained the probability of evidence being found of man at an earlier period than that of the post-glacial or quaternary

river gravels, but, as in all other cases, it appears to me desirable that the evidence brought forward should be thoroughly sifted and all probability of misapprehension removed before it is finally accepted. In the present state of our knowledge I do not feel confident that the evidence as to these three successive palæolithic deposits has arrived at this satisfactory stage. At the same time it must be borne in mind that if we make the palæolithic period to embrace not only the river gravels but the cave deposits of which the south of France furnishes such typical examples, its duration must have been of vast extent.

"In connection with the question of glacial and interglacial periods, I may mention that of climatal changes in general, which has formed another subject to which much attention has of late been given. The return of the Arctic Expedition, and the reports of the geological observations made during its progress, which have been published by Captain Feilden, one of the naturalists to the expedition, in conjunction with Mr. de Rance and Prof. Heer, have conferred additional interest on the question of possible changes in the position of the poles of the earth, and on kindred speculations. Near Discovery Harbour, about latitude 81° 40′, miocene beds were found containing a flora somewhat differing from that which was already known to exist within the Arctic regions. 'The Grinnell Land lignite,' say the authors of the report, 'indicates a thick peat moss, with *probably a small* lake, with water lilies on the surface of the water and reeds on the edges, with birches, poplars, and taxodiums on the banks, and with pines, firs, spruce, elms, and hazle bushes on the neighbouring hills. When we consider that all the genera here represented have their present limits at least from twelve to fifteen degrees further south, while the taxodium is now confined to Mexico and the south of the United States, such a sylvan landscape as that described seems entirely out of place in a district within six hundred miles of the pole, to which indeed, if land extended so far, these Arctic forests must have also extended in miocene times.' Making all allowance for the possibility of the habits of such plants being so changed that they could subsist without sunlight during six months of a winter of even longer duration, I cannot see how so high a temperature as that which appears necessary, especially for the evergreen varieties, could have been maintained, assuming that Grinnell Land was then as close to the North Pole as it is at the present day. Nor is this difficulty decreased when we look back to formations earlier than the miocene, for the flora of the secondary and palæozoic rocks of the Arctic regions is identical in character with that of the same rocks when occurring twenty or thirty degrees farther south, while corals, encrinites, and cephalopods of the carboniferous limestone are such as, from all analogy, might be supposed to indicate a warm climate.

"The general opinion of physicists as to the possibility of a

change in the position of the earth's axis has recently undergone modifications somewhat analogous in character to those which, in the opinion of some geologists, the position of the axis has itself undergone. Instead of a fixed dogma as to the impossibility of change we find a divergence of mathematical opinion, and variations of the pole differing in extent, allowed by different mathematicians who have of late gone into the question, as for instance, the Rev. J. F. Twisden, Mr. George Darwin, Prof. Haughton, the Rev. E. Hill, and Sir William Thomson. All agree in the theoretical possibility of a change in the geographical position of the earth's axis of rotation being effected by a redistribution of matter on the surface, but they do not appear to be all in accord as to the extent of such changes. Mr. Twisden, for instance, arrives at the conclusion that the elevation of a belt 20 degrees in width, such as that which I suggested in my presidential address to the Geological Society in 1876, would displace the axis by about ten miles only, while Prof. Haughton maintains that the elevation of two such continents as Europe and Asia would displace it by about 69 miles, and Sir W. Thomson has not only admitted but asserted as highly probable, that the poles may have been in ancient times 'very far from their present geographical position, and may have gradually shifted through 10, 20, 30, 40, or more degrees without at any time any perceptible sudden disturbance of either land or water.'

"I am glad to think that the question, to which I to some extent assisted to direct attention, has been so fully discussed, but I can hardly regard its discussion as being now finally closed. It appears to me doubtful whether eventually it will be found possible to concede to this globe that amount of solidity and rigidity which at present it is held to possess, and which, to my mind at all events, seems to be in entire disaccordance with many geological phenomena. Yet this, as the Rev. O. Fisher has remarked, is presupposed in all the numerical calculations which have been made. I am also doubtful whether in the calculations which have been made, sufficient regard has been shown to the fact that a great part of the exterior of our spheroidal globe consists of fluid which, though of course connected with the more solid part of the globe by gravity, is readily capable of readjusting itself upon its surface, and may, to a great extent, be left out of the account in considering what changes might arise from the disturbance of the equilibrium of the irregular spherical or spheroidal body which it partially covers. It appears to me also possible that some disturbances of equilibrium may take place in a mysterious manner by the redistribution of matter or otherwise in the interior of the globe. Captain F. J. Evans, arguing from the changes now going on in terrestrial magnetism, has suggested the possibility of some secular changes being due to internal, and not to external causes; and if it really be true that there is a

difference between the longest and shortest equatorial radii of the earth, amounting to 6,378 feet, such a fact would appear to point to a great want of homogeneity in the interior of our planet, and might suggest a possible cause for some disturbance of equilibrium.

"I have mentioned Prof. Haughton among those who, from mathematical considerations, have arrived at the conclusion that a geographical change in the position of the axis of rotation of the earth is not only possible but probable. In a recent paper, however, he has maintained that, notwithstanding this possibility or probability, we can demonstrate that the pole has not sensibly changed its position during geological periods. He arrives at this conclusion by pointing out that in the Parry Islands, Alaska and Spitzbergen, there are triassic and Jurassic deposits of much the same tropical character, and then by a geometrical method fixing the north pole somewhere near Pekin, and the south pole in Patagonia, within seven hundred miles of a spot where Jurassic ammonites occur, shows that such a theory is untenable. In the same way he fixes the pole in miocene times near Yakutsk, within eight hundred miles of certain miocene coal-beds of the Japanese islands. These objections are at first sight startling, but I think it will be found that if, instead of drawing great circles through certain points, we regard those points as merely isolated localities in a belt of considerable width, there is no need of fixing the pole of either the *Jurassic or the miocene* period with that amount of nicety with which Prof. Haughton has ascertained its position. The belt may indeed be made to contain the very places on which the objection is founded. Still the method proposed is a good one, and I hope that as our knowledge of foreign geology extends it may be still further pursued. There is, however, one further consideration to be urged, and that is as to the safety of regarding all deposits of one geological period as contemporaneous in time. Although an almost identical flora may be discovered in two widely-separated beds, it appears to me that chronologically they are more probably of different ages than absolutely contemporaneous; and, inasmuch as the duration of the miocene period must have been enormous, there would be time—if once we assume the wandering of the poles — for such wandering to have been considerable between the beginning and end of the period.

"I must not, however, detain you longer upon this phase of geological speculation, but will advert to a subject of more practical interest, the discovery of palæozoic rocks under London. So long ago as 1856 the Kentish Town boring had shown that immediately below the gault red and variegated sandstones and clays occurred, which Professor Prestwich regarded as probably of old red or Devonian age. The boring of Messrs. Meux and Co. has shown that under Tottenham Court Road, at a depth of little more than nine hundred feet from the surface, there are true Devonian beds, with characteristic fossils, and that Mr. Godwin Austen's prophecy of the

existence of palæozoic rocks at an accessible depth under London has proved true. Prof. Prestwich, from a consideration of the French and Belgian coal-fields, inclines to the belief that in the district north of London carboniferous strata may be found. Unfortunately the expense of conducting deep borings, even with the admirable appliances of the Diamond Boring Company, is so great that I almost despair of another experimental borehole, like that carried out in the Wealden district under the auspices of Mr. Willett, being undertaken.

"In the department of theoretical geology, I would call your attention to some experiments by M. Daubrée, of which he has given accounts at different times to the French Academy of Sciences. In these experiments he has attempted to reproduce on a small scale various geological phenomena, such as faulting, cleavage, jointing, and the elevation of mountain chains. Although the analogy between work in the laboratory and that on the grand scale of nature may not in all cases be perfect, yet these experiments are in the highest degree instructive, and reflect no little credit on the ingenuity of the distinguished chief of the Ecole des Mines.

"With regard to recent progress in palæontology, I must venture to refer you to Prof. Alleyne Nicholson's inaugural address lately delivered to the Edinburgh Geological Society, and I cannot pass over in silence the magnificent discoveries in North America, which are principally due to the researches of Profs. Marsh, Leidy, and Cope. The *Diceratherium*, a rhinoceros with two horns placed transversely, and the *Dinoceras*, somewhat allied to the elephant, but with six horns, arranged in pairs, are as marvellous as some of the beasts seen by Sir John Maundeville on his travels, or heard of by Pliny. But perhaps the most remarkable series of remains ever discovered are those which so completely link the existing horse with the *Eohippus* and *Orohippus*, and still further extend the pedigree of the genus *Equus*, which had already been some years ago so ably traced by Prof. Huxley.

"Of these American discoveries, as well as those made in the tertiary beds of Europe, M. Albert Gaudry has largely availed himself in his recent beautiful volume on the links in the animal world in geological times, a work which will long be a text book on the inter-relation of different orders, genera, and species. I am tempted to make use of some portions of M. Gaudry's own analysis of the book, which he communicated to the Geological Society of France. Beginning with the marsupials of the close of the secondary and beginning of the tertiary period, he shows that they are succeeded by such animals as the *Pterodon*, the *Hyænodon*, the *Proviverra*, and *Arctocyon*, which present a mixture of marsupial and placental characters, and to some extent justify a theory of the transition from one order to the other. He next examines the marine mammalia, and points out that, so far as at present known, they make their appearance later than those

of the land, and that the examination of the pelvis of the *Halitherium* tends to support the idea that the mammals, such as the sirenians, which at the present day have no hind limbs, are descended from terrestrial quadrupeds, for those limbs in the *Halitherium* are much less reduced than in its recent successors, the dugong and manatee. After tracing the numerous links which are to be found between the extinct and living pachydermata, he proceeds to show that, notwithstanding the great distance between them and the ruminants, transitions may be seen. The earliest ruminants were devoid of horns and antlers, but possessed upper incisors, and by a comparison of the molars of different genera it may readily be conceived how the large bosses of the omnivorous teeth of the pachyderms gradually shaded into the small crescents of the teeth of the ruminants. At the same time the passage from the heavy and complicated extremities of the limbs of the pachyderms to the simpler and lighter feet of the ruminants can be traced. The history of the horse family is also discussed, and the descent of existing proboscidians from the mastodons is shown to be probable, though the previous forms from which the mastodons and dinotheria are derived are as yet unknown. Nor can the origin of the carnivora as yet be suggested, though passages between the six existing families of the order may be observed. In conclusion, M. Gaudry devotes a chapter to the quadrumana, and thinks that palæontological observations tend to diminish the isolation in which these mammals now stand with regard to the other orders.

"One of the most important features insisted on by M. Gaudry is that to which I have already alluded—the development of the complicated molars of most mammals. His view is that by a comparison with early and with fœtal forms the probability may be shown of these compound teeth being made up of what in earlier forms were simple teeth—or, as he has termed them, denticules—which have coalesced in the same manner as have some other parts of the normal bony skeleton. In the compound teeth the denticules in some cases preserve their original conical form, as in the pig tribe; in others are elongated transversely, so as by their junction to form ridges, as in the tapirs; while in others, again, they are drawn out into longitudinal crescents, as in the ruminants. Between these forms there are, of course, innumerable transitions. They do not, however, appear to me to affect the importance of M. Gaudry's observations, which must be regarded as of the highest value in all attempts to trace the inter-relation of different forms of mammalian life. I must not, however, detain you longer on this subject, as I trust that I have said enough to show the importance and interest of this book.

"The discoveries of early forms of birds with teeth do not come within M. Gaudry's province; but Prof. Marsh has largely added to our knowledge of these remarkable forms. The tertiary *Odontopteryx toliapicus* from Sheppey,

described by Prof. Owen, seems rather to be endowed with bony tooth-like processes in the jaw than actual teeth, and the head of the *Argillornis* from the same locality is at present unknown. But the *Hesperornis* and *Ichthyornis* from the cretaceous beds of America possess veritable teeth, in the one case set in a long groove in the jaw, and in the other in actual sockets. Such intermediate, or, as Prof. Huxley would term them, intercalary forms, tend materially to bridge over the gap which at first sight appears to exist between reptiles and birds, but which to many palæontologists was far from being impassable, long before the discoveries just mentioned. The amphicœlous character of the vertebræ of *Ichthyornis* presents another most remarkable peculiarity, which is also of high significance. I hear rumours of the discovery of another *Archæopteryx* in the Solenhofen slates, which is said to present the head in a much more complete condition than that in which it occurs on the magnificent slab now in the British Museum. As yet, I believe, the jaws have not had the matrix removed from them; but should they prove to be armed with teeth, it will to me be a cause of satisfaction rather than surprise, as confirming an opinion which, some fifteen years ago, I ventured to express, that this remarkable creature may have been endowed with teeth, either in lieu of or combined with a beak."

The Geology of Gibraltar.—At the Meeting of the Geological Society on March 6th, 1878, an interesting paper on the "Geology of Gibraltar," by Prof. A. C, Ramsay and Mr. James Geikie, was read. The chief rock is a pale grey bedded limestone, overlain by shales containing beds and bands of grit, mudstone, and limestone. Fossils are rarely met with in the latter, and have never been found in the shales. The only recognisable fossil obtained from the limestone was Rhynchonella concinna, which would make the beds of Jurassic age All round the rocks are platforms, ledges, and plateaus, evidently the work of the sea, which would serve to show that the rock has been depressed and then re-elevated. A discussion followed the reading of the paper, the authors saying that there was some reason to think that Europe must have been again united to Africa after the first separation.

VI.—METEOROLOGY.

The Range of Temperature in Sweden.—In the *Austrian Journal* for March 15, 1878, Prof. Rubenson gives an abstract of a recent paper by himself in the *Transactions* of the Swedish Academy on this subject. He draws the following conclusions: The least variation occurs everywhere in December or January; the greatest in June or July, except in the west, where it takes place in May, and in the northern district, where a more strongly marked maximum is noticed in March. The climatic contrasts come out most emphatically in the summer. In winter the conditions of range are nearly uniform over the whole kingdom.

English Health Resorts in Winter Time.—A paper "On the Winter Climate of some English Seaside Health Resorts (Torquay, Penzance, Guernsey, Barnstaple, Ventnor, Llandudno, Ramsgate, and Hastings), was read by Dr. Tripe before the Meteorological Society, on the evening of 20th February, 1878. The results may be briefly summed up as follows, viz, the mean daily winter temperature of these seaside places, and especially of those situated on the coast of Devon and Scilly, is higher than at London; the mean daily maxima and minima are also higher, and especially the latter, so that the daily and monthly ranges of temperature are smaller; the mean humidity is less, the general direction of the wind about the same, but the number of rainy days and the rainfall are greater at the seaside. As regards the wind, therefore, the chief point to be especially noticed is the amount of shelter afforded by high land as at Ventnor, and especially of protection against the stormy and cold winds which ordinarily prevail at the end of February and in March. The soil also should be considered, as heavy rains at gravelly and chalky places are not so objectionable as on clayey ground.

Falls of Dust on the Atlantic.—About the latitude of the Cape Verde Islands, on the Atlantic, it is a frequent experience of voyagers to observe falls of red dust and a dry kind of mist. The material of the dust-mass was examined microscopically many years ago by Ehrenberg, and his opinion was that small particles carried aloft from all countries here formed a transparent dust zone, from which they sometimes sank down, and in whirling movement came to the earth's surface. The material of observation open to Ehrenberg was somewhat scanty. The phenomenon has therefore been lately studied anew, and in a more thorough way, by Herr Hellmann, who examined the log-books of 1,196 ships that had passed through the region in question during the years 1854 to 1871. He deals with the case chiefly from a meteorological point of view

and the following are some of the facts elicited, Most of the dust-falls occur in the zone of the Atlantic between 9° and 16° N. South of 6° N. they are extremely rare, and the furthest south hitherto was in 2° 56′ N., 26° W. The two furthest west were both in 38° 5′ W., both about 300 miles from Cape Verde. Dust-falls often occur simultaneously at very different points of the "Dunkel Meer," or Dark Sea (as Ehrenberg called it); in one case they were 150 miles apart. They also often last for several days, *e.g.* ten (April, 1859). Surfaces of very different size, up to 100,000 square miles, may receive dust-falls. There is a yearly period in the frequency of the falls. It seems that near the African coast most occur in winter; further west, in the early spring. The direction of the wind during dust-falls was from the east quadrant, and most frequently N.N.E. to N.E. The dust-falls observed are very irregularly distributed over the years in question. Of 63, taken at random, there were eight falls of sand and three of sand or dust. Sometimes sand and dust fall simultaneously. The dust-falls with great extent east and west are denser the nearer the African coast. In 40 out of 65 instances the colour of the dust was red. Sometimes there is no colouration. The dry mist of the Dark Sea is in casual connection with the dust-falls. Herr Hellmann concludes from the facts that the dust material comes principally from Africa and from the Western Sahara. The possibility of *occasional mixture of* particles *from South America is* not *excluded. The distribution* of the dust-falls, both in space and in time (they follow the movements of the trade winds), supports the hypothesis, as also does the fact that the falling material is coarser in the east than in the west.

On Certain Phenomena accompanying Rainbows.—A paper on this subject was read before the British Association, by Prof. Silvanus P. Thompson. The author narrated several instances of rainbows seen chiefly in Switzerland, where radial streaks of light devoid of colour were observed within the primary and without the secondary bow. The explanation suggested was as follows:—The wedge-shaped radial streaks are beams of sunlight, which become visible by diffuse reflection from particles of matter in their path, just as the apparently divergent beams of sunrise or sunset become visible. These "beams" being practically parallel to one another, appear to converge in the point exactly opposite to the sun by perspective, or, in fact, just as the parallel beams of sunset appear divergent. Since the rainbow has for its centre the point opposite the sun, such beams must have positions radial with respect to the bow. They resemble, therefore, the *rayons du crépuscule* occasionally seen in the east at sunset; they had never been observed crossing the dark span between the primary and secondary bows. A similar phenomenon of rays might sometimes be seen in sunlight, when the shadow of the observer fell upon a slightly turbid lake or river.

Influence of Electricity on Evaporation.—Since it was proved

that there is electricity in the air, both in time of storms and under ordinary conditions, many physicists have sought its origin. It has been chiefly attributed to vaporisation of water, but this now seems doubtful. Thus, in tumultuous boiling which no doubt causes electrification, solid or liquid particles are thrown against the walls; and where this cause of friction is avoided all trace of electricity disappears. And a very slow evaporation must furnish very little electricity. M. Mascart has lately approached the subject from another point, and studied the influence of electricity on evaporation. He placed a number of basins of water or moist earth under conductors of grating form, connected with a Holtz machine, which was driven by a water engine, and enclosed in a case, the air of which was kept dry; the basins too, were enclosed in a case in which the air was regularly dried. The conductors were kept at constant potential. The evaporation was always increased under this action, whatever the sign of the electricity; in some cases it was even doubled. If the temperature vary considerably in the inclosure in which the basins are placed the influence of the electricity is entirely veiled.

Optical Phenomena.—A curious optical phenomenon was observed early in 1878, on the coast of Florida, at Key West. The temperature of the sea was about nine degrees under that of the lower atmospheric layer, and this difference produced on the surface a condensed layer of vapour, on which the sun's rays fell obliquely. The upper limit of this layer, which was only a few mètres in thickness, was confounded at a distance with the surface of the water, so that vessels seemed to pass into the sea; their hulls gradually disappeared, while their masts and rigging stood out distinctly against the sky. A correspondent of *La Nature* describes the phenomenon of a vertical luminous column above the rising sun, as observed by him recently at Logelbach (Alsace). It measured 2° to 2·5°, and was of a cindery red at the horizon, changing to orange red at the upper part. Its brightness varied little from 6.30 to 7 a.m., during which time it was transported horizontally from 4° to 5°. A minute after the sun rose the column shrank to a rudimentary form.

VII.—HEAT.

Cookery by the Sun's Rays.—A joint roasted by the heat of the sun was one of the chief attractions of the grounds of the Paris Exhibition of 1878, where M. Mouchot, a Tours professor, when the clouds permitted, daily cooked a portion of meat by means of a strong reflector. He ordinarily succeeded in boiling sufficient water for three cups of coffee in three quarters of an hour. In Algeria, where the sun naturally possesses greater power, Professor Mouchot has roasted quails in twenty minutes.

Temperature of Flames.—In the *Gazetta chimica Italiana* an account is given by F. Rosetti of some experiments on the above subject. To examine the temperatures he employs a thermo-electric element consisting of an iron and a platinum wire wound closely together and connected with the galvanometer. This latter was graduated to various temperatures by observing the deviation consequent on bringing the element in contact with a copper cylinder heated to known temperatures; these being determined by introducing the cylinder into a calorimeter. With such an arrangement he has investigated the flame of a Bunsen's burner, finding that in the same horizontal strata there were but slight alterations in the temperature, with the exception of the dark interior portion. Thus, where the external envelope showed 1,350°, the violet portion of the flame was 1,250°, the blue 1,200°, but the internal portion much lower, its temperature gradually decreasing from the base of the flame upwards. A flame produced by the combustion of a mixture of two volumes of illuminating gas and three volumes of carbonic oxide, showed a temperature of 1,000°.

Reflection of Heat by Metals.—In the first part of the new series of *Poggendorff's Annalen* is an account of Knoblauch's most recent experiments on the reflection of heat by metals. The metals examined were steel, nickel, zinc, copper, gold, silver and brass, The sun was used as a source of heat, the solar beam being directed by a heliostat and polarised by Nicol's prism. The intensity of the reflected heat varies with the incidence. It increases with the incidence when the heat is polarised parallel, or at 45°, to the plane of incidence, though the increase is less sensible in the latter case. For heat polarised perpendicular to the plane of incidence, the intensity at first decreases with the incidence up to the angle of polarisation, and then increases. For the same angle of incidence the intensity of the reflected heat is always least with the polarisation at 45°, and less when the polarisation is perpendicular than when it is parallel

to the plane of incidence. In respect of the reflection of heat, different metals present very different properties. The differences of intensity, well marked in the case of steel or nickel, almost vanish with brass. This last substance communicates by reflection to unpolarised heat circular polarisation; the other metals, as we know, elliptic polarisation; while glass gives plane polarisation.

Invisible Heat—The Solar Spectrum.—Professor Tyndall, in the conclusion of a series of lectures on heat, delivered by him at the Royal Institution, in the winter of 1877-78, alluded to the remarkable analogy between light and heat, especially in regard to their transmission through solid and liquid bodies. After illustrating this, by a plate of rock salt and some liquid bisulphide of carbon, the Professor showed that bodies transparent to light vary in regard to heat; that some are even opaque to heat, while others, opaque to light, allow a comparatively free passage to heat. For instance, this property, termed "diathermancy," is not possessed by water and glass, while lamp-black allows the invisible heat to pass freely. Having produced a magnificent spectrum from the electric lamp, Dr. Tyndall demonstrated, by means of his thermopile, and other arrangements, that the radiation of heat from the spectrum gradually rising, extends far beyond the red end till it attains its maximum. These invisible rays, or waves of darkness, are highly important agents in nature. They are given off by the earth as well as by the sun, and are largely engaged in the work of evaporation, giving rise to clouds, rain, dew, and snow. By making use of a heat-filter (such as a solution of iodine in bisulphide of carbon, or iodine and sulphur fused together) the focus of the light rays of the electric lamp was intercepted, and that of the invisible heat rays left; and by this invisible focus platinum foil was made incandescent, gun-cotton exploded, paper burnt, and charcoal in oxygen gas ignited, while the air at the focus remained as cool as at any other part of the room. Having explained that the spectrum of the coke-points of the electric lamp is continuous from the red to the blue, the Professor showed that the spectrum of an incandescent metallic vapour, such as that of boiling silver, consists of one or more definite luminous bands, with non-luminous spaces between them; these bands being perfectly characteristic of each metal. He then described how the solar spectrum had been discovered to be crossed by innumerable dark lines, the rays corresponding to which are absent; and how Kirchhoff had explained these lines by reference to the reciprocity of radiation and absorption. Thus the yellow band in the spectrum, attributed to sodium vapour, was absorbed, and a black line substituted, when a sodium flame was introduced in the path of the rays of the lamp. By the study of these dark lines new metals have been discovered, and a new theory of the constitution of the sun has been arrived at.

VIII.—LIGHT AND VISION.

Is the Human Eye changing its Form under the Influence of Modern Education?—A pamphlet with this title was published in the winter of 1877–78, by Dr. Loring, of New York. It is his object to draw general attention to the bad effects of over-study during childhood on the organ of vision, effects seemingly proportionate to the degree in which the principle of compulsory education is carried out. Myopia, or shortsightedness, consists essentially in an elongation of the antero-posterior diameter of the eye-ball. A systematic examination of the eyes in large numbers of children attending public schools in Germany, Russia, and the United States, has conclusively shown that school-work is a powerful—perhaps the most powerful—cause of myopia. Again, Prof. Ribot says, in his work on *Heredity*:—"Since constant study creates myopia, and heredity most frequently perpetuates it, the number of short sighted persons must necessarily increase in a nation devoted to intellectual pursuits." Their number actually has increased to an alarming extent in Germany. Is there any danger of myopia becoming the rule, and normal vision the exception, throughout the civilised world? Of the two factors required to produce such a result, one—heredity—is thought by Loring to be less universally operative than Ribot has assumed it to be. The tendency to inherit a myopic eyeball is largely counteracted by the opposite tendency to revert to a type already perfect in its adaptation to its environment. Only by altering some important "condition of existence" may this conservative tendency be nullified; and the alteration must be brought to bear not on a few individuals only, but on the great mass of the community; not one sex only, but on both sexes alike. Universal compulsory education is a condition of this kind, and it is making its influence felt already. It causes myopia in the individual by compelling over-use of the eyes in childhood and early youth; it favours the hereditary transmission of the defect by lessening the tendency to revert to the normal type of eye-ball.—*Academy.*

Colour-Blindness.—Colour-blindness, or "Daltonism," is not uncommon in France. M. Favre's studies at the Académie des Sciences prove that no fewer than 3,000,000 persons across the channel are afflicted with inability to distinguish colours. Women are far more predisposed to this affection than men, the proportion of the latter being only 10 per cent. Nine cases out of ten may be cured in young patients, the best mode of treatment consisting of methodical exercises upon coloured objects.

The Effect of Gaslight on the Eyes.—A report on the effect of gaslight upon the eyes has recently been laid before the German Minister for Education by the Scientific Committee for Medical Affairs. The conclusions arrived at are that, according to present experience, gaslight has no prejudicial effect upon the eyes, provided they are sufficiently protected from its direct action. For this purpose the committee recommend shades and bell-glasses of translucent glass-porcelain. On the other hand, they disapprove of opaque metallic shades, since, when these are used, the eyes, though themselves in shade, gaze upon a strongly-illumined surface, and become dazzled and over-stimulated. On account of the large quantity of heat evolved by gas, the burner should not be too near to the heads of persons in the room; the heat is liable to cause headache, and even congestion of the brain. Care should also be taken to prevent the flame from flickering, which is often a source of mischief and annoyance. When there is any particularly irritable condition of the eyes, a dark blue glass will be found advantageous. The committee believe that, with these precautions, gaslight may be used without fear of mischief.—*Medical Examiner.*

A New Direct-Vision Spectroscope.—A new direct-vision spectroscope, by M. Thollon, is based on the idea of sending the light rays first through one (say the lower) half of the prisms, then, *by total reflection,* twice at the *surfaces of a rectangular* prism, *elevating them* and reversing their direction, so that the bundle of rays returns by the upper half of the prisms. M. Thollon arranges two prism systems of this kind symmetrically to the common axis of the collimation and observation tubes, causes the rays by total reflection to be deflected about 90°, and pass to and fro through the first system of prisms, the return being at the higher level. The rays next pass into the upper half of the second prism system beyond the optical axis, return from this to the original level, and are thrown by a further total reflection into the observation tube.

Persistence of Images on the Retina.—About the beginning of 1877, Dr. Boll threw some new light on the structure of the retina by the discovery of a substance of purple colour in the last retinal layer, in which a portion of the "rods" is engaged. It had escaped notice before, because of its very rapid disappearance on the action of light. Dr. Boll felt himself warranted in saying that the formation of images on the retina was a veritable photography. Subsequently Dr. Kühne discovered the organ by which this purple is incessantly reproduced—viz., the mosaic layer, or thexagonal epithelium of the choroid, which, therefore, it has been proposed to call the retinal epithelium. M. Giraud Teulon, in a recent report, calls attention to some modifications in theory required by the unlooked-for physiological function, referred to. Thus as regards the persistence of positive images (*i.e.* the continuance of the sensation after the impression that produced it), the simple fact of chemical de-

coloration of the retinal purple by the light, involving a certain time for its reconstitution, by the secreting action of the mosaic layer, gives a sufficient account of the phenomenon. Then, as to accidental negative images and their successive phases of coloration, the photo-chemical theory replaces Young's perfectly arbitrary explanation, based on three supposed different kinds of fibres, by a simpler one, which is this:—A given monochromatic light chemically alters, in a constant and uniform way, the retinal purple which it encounters. Now, the rod, or primitive nerve-element, has its base immersed in the bath formed of this substance. We have only, then, to suppose in this element the power of feeling, in a different way, the intimate contact of different media, exactly as the *papillæ* of the nerves of special sensibility (like those of smell and taste, for example) appreciate or carry to the sensorium stimulations as varied as is the nature of the liquids or effluvia which come to them. When the primary cause, the luminous object, is withdrawn, the nerve fibre, according to the progress of the reconstitution of the purple, announces by successive testimonies the gradual renewal of the normal bath.

An Optical Illusion.—An optical illusion recently described by M. Trappe gives an interesting proof that we base our judgment on the distance of an object chiefly on the amount of convergence of the optical axes in looking at it. Also, that our judgment on the size of an object *depends on our idea* of its distance. *Standing* on a staircase, M. Trappe looked towards a ground glass window, about 1½m. off, which had regular horizontal rows of transparent stars on it, and tried for some time to look through the stars at a house several hundred paces distant. The window then appeared, not 1½m. off, but from 3 to 4m., and when he directed his attention only to the window he could with some effort contemplate the window panes and their stars without the illusion as to their distance ceasing. Thereupon the individual stars and their distance seemed increased in the same measure as the distance of the window. When he approached the latter, the stars seemed to approach him first like one's image in a plane mirror when one walks towards it. M. Trappe, in explanation, points out that to see the house was possible only by causing the optical axes to pass, not through one star but through two neighbouring stars. The images of the two stars were then produced on the retina as if they were simply that of one star. The two stars appear as one, at that distance from the observer, where the optical axes meet—that is, some way behind the place where they are actually.—*English Mechanic.*

Polarisation of Light—Quartz. — Mr. William Spottiswoode, LL.D., F.R.S., secretary R.I., delivered a discourse at the Royal Institution on the evening of the 5th of April, 1878. Mr. Spottiswoode's object was to exhibit, under new experimental forms, some of the fundamental laws of the action of quartz upon polarised

light. After some introductory remarks on polarisation, with illustrations, he showed how, by using a sphere of Iceland spar, instead of a second Nicol's prism, as the analyser, he had succeeded in exhibiting simultaneously to the eye all the beautiful chromatic effects, and especially the rotation of the plane of polarisation by quartz, which are usually only seen in succession. In his course of lectures on polarised light given at the Royal Institution in 1876 he produced part of his present results by means of a revolving double-image prism; but now, by means of the sphere, all necessity for mechanical movement was avoided. The result of a combination of right-handed and left-handed quartz was shown by a compound plate formed by a solid cone of right-handed quartz fitting into a hollow cone of left-handed quartz; and a very curious optical illusion in the change of colours, due to a rotation of the analyser, was exhibited and explained. The spectrum of the light transmitted by this plate was exceedingly intricate, and in its dark lines resembled the tracery of a Gothic window. The subject was still further illustrated by two plates of right-handed and left-handed quartz respectively, each composed of sectors of different thickness, so disposed that any sector of the one could be brought in front of any sector of the other. It would be impossible to describe in detail all the gorgeous effects of colour which were produced, the results being truly magical in appearance, yet all being strictly in accordance with scientific laws, based upon the facts which have been discovered by profound study of the varied forms of polarisation of light, for which Mr. Spottiswoode is so justly eminent.

Luminous Perceptions.—At a Meeting of the French Physical Society, M. Rosenstiehl described the results he had obtained through use of rotating discs for study of luminous perceptions. He stated, *inter alia*, that white light mixing its impression with that of a colouring matter, tarnishes the colour of the latter the more the larger the angle of the white sector employed. Absolute black, far from tarnishing the colour of a colouring matter, deepens it, while preserving all the vivacity. Hence, a colouring matter, however bright the colour, may totally extinguish a portion of white light without one perceiving it; it is only in mixing the white light that this extinction becomes visible. *En résumé*, every colouring matter totally extinguishes a part of the incident white light; the colour of the colouring matter varies with the thickness under which it is viewed; it is nearer the red the greater this thickness, nearer the green the smaller the thickness.

IX.—SOUND.

Edmonds' Phonoscope.—This little instrument, the phonoscope, is for producing figures of light from vibrations of sound, and was described at the Dublin Meeting of the British Association by Mr. Ladd. It consists essentially of three parts—an induction coil, an interrupter, and a rotary vacuum tube. The action of the instrument is as follows:—Sounds from the voice or other sources produce vibrations on the diaphragm of the interrupter, which, being in the primary circuit of the induction coil, induce at each interruption a current in the secondary coil, similar to the action of a contact-breaker or rheotome; therefore each vibration is made visible as a flash in the vacuum tube. The tube revolving all the time at a constant speed, the flashes produce a symmetrical figure like the spokes of a wheel, as in the Gassiot Star. The number of spokes or radii is according to the number of vibrations in the interrupter during a revolution of the tube, and on the number of vibrations being varied to any extent according to the sounds produced the figures in the revolving tube will be varied accordingly. The same sounds always produce the same figures, providing the revolution be constant. In cases of rhythmical interruption being produced in a given sound, as in a trill, most beautiful effects are noticeable, owing to the omission of certain radii in regular positions in the figure.

Musical Tones in Air and Water.—When a struck tuning-fork is quickly immersed in a vessel of water one hears—especially if he places his ear on the resonant table—a tone, the pitch of which does not agree with that of the tuning-fork in air. From theoretical considerations M. Auerbach lately concluded that the tone must be lowered, and that the tones in air and water must be as 1·18 to 1, or as 7 : 6, the interval being thus greater than a whole tone, and less than a minor third. Experiment showed that the interval approximates this value as maximum, but on an average is somewhat less. The approximation is greater the smaller the period of vibration. These researches are described in Wiedemann's "Annalen."

Necessary Vibrations.—No definite limit of audibility has ever been assigned for sounds of low pitch, but it has been generally accepted that an organ-pipe of 32 feet gave the lowest sound that could be utilized—that is, a note produced by 16 vibrations per second. According to Professor Pfaundler, of Vienna, the smallest absolute number of vibrations capable of producing a sound is two, but those must be repeated again and again to obtain an audible tone. He arrived at this

conclusion after making a series of experiments by means of a siren with two apertures.

Professor Bell on the Telephone. — At a Meeting of the Physical Society held on the 1st of December, 1877, Prof. G. Bell exhibited and described the telephone, prefacing his account by a sketch of the progress of electric telephony. Reiss was the first to employ the human voice in his experiments. Prof. Bell examined the phenomena which take place when sounds are transmitted through the air. It is, of course, not the motion of the vocal organs themselves that is received in the ear, but that of the air set in motion by their means, and all peculiarities in the sound must be peculiarities in the motion of that air. If the rapidity of motion varies, it occasions a variation in the pitch, and the loudness is changed by changing the amplitude. The shape of the vibration produces *timbre*. If by moving the air in certain specified ways certain vowel sounds are given out, then those same sounds will be emitted if an identical movement be occasioned by any mechanical means whatever, and Prof. Bell has found that such a motion may really be given to the air in various ways.

Three classes of electrical currents have been employed for transmitting sounds to a distance, and these he denominates intermittent, pulsatory, and undulatory. The first form is obtained when a current passes for a brief interval, and is then followed by an interval during which no current passes, and this by a current of the same or opposite sign. In the second class a current is continually passing, but its intensity increases and decreases instantaneously; and, finally, in the third class, this variation takes place gradually, and may, therefore, be represented by a sinuous line. In his experiments on the nature of the movement of the air, Prof. Bell employed a human ear, a hay style attached to the incus recording the movement communicated to it on a moving sheet of smoked glass. A very interesting series of curves produced by this means was shown on the screen, and he explained how his experiments in this direction led him to the present form of telephone. Since the very small membrane of the ear was capable of setting in motion comparatively large bones, it seemed probable that it could cause a light piece of iron to vibrate. In the earlier form of apparatus a piece of steel spring was therefore attached to a stretched membrane of gold-beater's skin, and placed in front of the pole of the magnet, but he found on increasing the area of metal that the action of the instrument was improved, and thus was led to do away with the membrane itself.

Another branch of the investigation referred to the strength of the magnet employed, and this was modified by varying the strength of current. The battery was gradually reduced from 50 cells to none at all, and still the effects were observed in a much less marked degree; the action was in this latter case doubtless due to residual magnetism, hence in the present form of apparatus a permanent magnet is employed.

Lastly, the effect of varying the dimensions of the coil of wire was studied, when it was found that the sounds became louder as its length was diminished. A certain length was, however, ultimately reached, beyond which no improvement was effected, and it was found to be only necessary to enclose one end of the magnet in the coil of wire.

A number of diagrams were projected on to the screen, which showed the various forms the apparatus has taken from the time of Page to the present day. An air sung in a distant part of the building was distinctly heard in the room by the aid of an improved form of Reiss's telephone, lent by Prof. Barrett, and made by Mr. Yates, of Dublin. Prof. Bell, Prof. Foster, and Dr. Gladstone then carried on a conversation with a gentleman at a distance, and utterances were shown to be audible when the transmitting instrument was held about a foot from the mouth.

In replying to various questions, Prof. Bell stated that his attempts to determine the amplitude of the vibrations had not been successful, and he is coming to the conclusion that the movement must be molecular. Very distinct sounds are emitted when a considerable mass of iron is employed, and, further, if the iron be glued to a piece of wood an inch thick, and this be interposed between it and the magnet, the action still continues. Conversation has been carried on through a distance of 258 miles, but a resistance of 60,000 ohms has been interposed without preventing the action. There is a very marked difference in the manner in which letters are reproduced by the telephone. Vowel sounds are more acceptable than consonants, and, as a rule, those letters are best transmitted which involve a large oral aperture in their utterance. Finally, he finds that high sounds are produced more fully than low ones, but this question has not yet received sufficient attention.—*Athenæum.*

Some Physical Considerations connected with the Telephone.—At a meeting of the Physical Society in London in the winter of 1877-78, Mr. W. H. Preece read a paper on some physical considerations connected with the telephone. He first referred to the instrument as one which puts in the hands of electricians a new apparatus for research, and which, for the examination of certain kinds of electricity, is the most delicate yet invented. It makes possible the investigation of currents, which though suspected, have till now eluded the grasp of the electrician. It is further a generator of a species of current that has hitherto not been known, and it is therefore novel and unique as a source of electricity. Faraday first studied the phenomena, giving the key to the explanation of the generation of the currents by the telephone, though they are here in a much more delicate degree. So delicate are the vibrations of the disc, so small is their amplitude, that the means at present known for such purposes cannot measure them, even in an approximate degree.

The paper then passed on to the consideration of the apparatus for the practical purposes of oral

communication at a distance. It has been noticed how great is the difference in the power of different voices to make themselves heard. This power depends on a clear intonation and a distinct articulation; mere shouting is of no use, and for effectually working the telephone a voice needs a special training. Mr. Preece said he had been able to hear the voice of one of the staff when it was completely blocked to all others.

For many months past careful study has been made with regard to possible improvements that may be made. All attempts to increase the power have so far failed, and changes in the form, size, and power of the magnet employed do not seem to produce any effect. One of the greatest difficulties to be overcome is the readiness with which induced currents produce sound. Though it is easy to hear distinctly with a wire 100 miles long, it is not possible to do so with a cable of 20 miles when placed in a coil; the induced currents interfere. With a view of overcoming this difficulty, Mr. Edison, in America, has been trying to obtain an intensity in the transmitted current, and Mr. Preece has turned his attention rather to screening one wire from another. He explained the theory of the screening, and a cable has been for some time in construction under his direction, but there has been no opportunity of testing it. It has also been found that a return wire will neutralise the effect of induction. Such slight currents produce such effects that a perfect insulation of wire is found difficult, just as perfect communication to earth is. The electric disturbance caused by a flash of lightning near one end will cause a current sufficient to produce sound at the other. Mr. Preece believes that the experiments which have been made give hope for the practical use of the instrument at great distances.

More about the Telephone.—At a Meeting of the Royal United Service Institution, in December, 1877, a lecture was given by Mr. W. H. Preece, of the Postal Telegraphs, on the telephone and its application to military and naval purposes. He pointed out the enormous value of the electric telegraph for warlike purposes. "It has well-nigh revolutionized the art of war. It has become a great weapon of offence, as well as a great shield of defence. Operations that were a few years ago impossible are now regarded as essential. The strategist in his office can now grasp a continent in his combinations. The actual manœuvres of armies can be controlled and directed like the toy figures of the game of kriegsspiel. The maintenance of the lines of telegraph to an army in the field is as important as that of the more material lines of communication. The telegraph, in fact, has become a necessity of the age. No war could now be undertaken without its aid. Moreover, it facilitates the supply of food, it regulates the traffic on railways, and it aids the transport home of the sick and wounded; it satisfies the craving for news, and it alleviates anxiety. So important is efficient telegraphy now considered for the British Army that six officers and 160 men are being trained and main-

tained in efficiency in the British postal telegraph system, so as to be available in time of war. They are, in fact, daily rehearsing that part which they may have some day to perform in earnest in an enemy's country. Moreover, we have our field telegraphs in constant training at Aldershot, Chatham, and elsewhere, though it is very doubtful whether this department has been nearly sufficiently developed, or is anything like being properly equipped, for such an army as ours." The present system in use for field telegraphy is the Morse recording apparatus, which needs trained men. The telephone requires no training. It has, further, this advantage—that no tricks can be played by an enemy "tapping" the line, as the voice of the sender of a message can be recognized.

The greater part of the lecture was occupied with the principles of sound-waves, and the way in which the electric telephone reproduces sound, with all the qualities of *timbre* and modulation at a distance. In illustrating how a telephone acts, the different parts—the magnet, coil, and iron disc—were shown separately and then put together. The great simplicity so impressed the audience, that the description was followed by warm applause. "How far the telephone can be employed in warfare remains to be seen. We do know this—that it transmits to a distance far beyond the reach of the ear, or of the eye, the words of command, the tones of voice, the distinct and unmistakable articulations of the general as well as of the private. Such an apparatus must be valuable for military purposes. How far it can be utilized for naval purposes remains to be seen. Wherever a wire can extend there can the voice be sent. In communicating between the bridge and the wheel, between the turret and the engine-room, between the look-out and the officer of the watch, it ought to be useful. For diving operations it is invaluable. In torpedo operations and range-finding it may prove useful. But at present it is a mere child. It has startled us all by its novelty, its beauty, and its simplicity. Time alone is required to establish its utility. Probably no instrument that has ever been devised has created more sensation, or has attracted so much attention."

A Signalling Apparatus for the Telephone.—A signalling apparatus for the telephone has recently been devised by Dr. Pulieg, of Vienna, and has the following arrangement: — Two telephones, without sounding pieces, are connected together, and placed with their bobbins opposite two tuning forks of exactly the same pitch. On the opposite side of each of the tuning forks is placed a metallic bell. Between this and the fork, and resting against the latter, hangs by a thread a small brass ball. The tuning fork at the sending station is struck with a leather-covered iron hammer, whereupon the fork at the receiving station is also put in vibration, and causes the ball to strike on the bell. The signal having been answered in the same way from the receiving station, the sounding pieces (which include the iron membranes) are adjusted, and the correspondence begins. The

bell signal is so strong that with closed doors one may hear it in an adjoining room. — *English Mechanic.*

The Phonograph. — In the course of 1877 we were startled by the announcement that we could converse audibly with each other, although hundreds of miles apart, by means of so many miles of wire with a little electro-magnet at each end. And before the year was out we had another wonder to speak of—an invention, purely mechanical in its nature, by means of which words spoken by the human voice can be, so to speak, stored up and reproduced at will over and over again, hundreds, it may be thousands, of times. What will be thought of a piece of mechanism by means of which a message of any length can be spoken on to a plate of metal, that plate sent by post to any part of the world, and the message absolutely re-spoken in the very voice of the sender purely by mechanical agency? What, too, shall be said of a mere machine by means of which the old familiar voice of one who is no longer with us on earth can be heard speaking to us in the very tones and measure to which our ears were once accustomed?

The highly ingenious apparatus by which this wonder is effected is the invention of Mr. Thomas A. Edison, of Manlowe Park, New Jersey, U.S.A., the electrical adviser to the Western Union Telegraph Company. Mr. Edison is well known in the States, and scarcely less so in England, for several valuable practical applications of electrical science, among *Mr. Edison's other* inventions being an exceedingly well-arranged telephone. To the present invention Mr. Edison has given the name of the phonograph, and it depends for its action upon certain well-known laws in acoustics.

The phonograph is composed of three parts mainly—namely, a receiving, a recording, and a transmitting apparatus. The receiving apparatus consists of a curved tube, one end of which is fitted with a mouthpiece for the convenience of speaking into it. The other end is about two inches in diameter, and is closed in with a disc or diaphragm of exceedingly thin metal, capable of being thrust slightly outwards or vibrated upon gentle pressure being applied to it from within the tube. To the centre of this diaphragm—which forms a right angle with the horizon—is fixed a small blunt steel pin, which, of course, partakes of the vibratory motion of the diaphragm. This arrangement is carried on a table and is fitted with a set screw, by means of which it can be adjusted relatively to the second part of the apparatus—the recorder. This is a brass cylinder, about four inches in length and four inches in diameter, cut with a continuous V groove from one end to the other, so that it in effect represents a large screw. Measuring along this cylinder from one end to the other there are 10 of these grooves to the inch, or about 40 in the whole length. The total length of this continuous groove, or screw-thread, is about 42 feet—that is to say, that would be the length of the groove if it were stretched out in a straight line. This cylinder is mounted on a

horizontal axis or shaft, carried in bearings at either end, and having its circumferential face presented to the steel point of the receiving apparatus. The shaft is prolonged for four inches or so beyond the ends of the cylinder, and one of the prolongations is cut with a screw thread and works with a screwed bearing. This end terminates in a handle, and as this is turned round the cylinder is not only revolved, but by means of the screwed spindle is caused to travel its whole length in front of the steel point, either backwards or forwards.

We now see that if the pointer be set in the groove in the cylinder at its commencement, and the handle turned, the groove would be traversed over the point from beginning to end, or conversely, the point would always be presented to the groove. A voice speaking in the receiver would produce waves of sound which would cause the point to enter to greater or less depths into this groove, according to the degree of intensity given to the pressure upon the diaphragm set up by the vibrations of the sound produced. This of course, of itself, would mean nothing; but in order to arrest and preserve these sound-pressures a sheet of tin-foil is interposed, the foil being inelastic and well adapted for receiving impressions. This sheet is placed around the cylinder and its edges lightly fastened together by mouth-glue, forming an endless band, and held on the cylinder at the edges by the india-rubber rings. If a person now speaks into the receiving-tube and the handle of the cylinder be turned, it will be seen that the vibrations of the pointer will be impressed upon that portion of the tin-foil over the hollow groove and retained by it. These impressions will be more or less deeply marked according to the modulations and inflexions of the speaker's voice. We have now a message verbally imprinted upon a strip of metal. Sound has, in fact, been converted into visible form, and we have now to translate that message by reconverting it into sound. We are about, in effect, to hear our own voice speaking from a machine the words which have just fallen from our lips. To do this we require the third portion of Mr. Edison's apparatus—the transmittor.

This consists of what may be called a conical metal drum, having its larger end open, the smaller end, which is about 2 in. in diameter, being covered with paper, which is stretched taut as is the parchment of a drum-head. Just in front of this paper diaphragm is a light, flat steel spring, held in a vertical position and terminating in a blunt steel point projecting from it, and corresponding with that on the diaphragm of the receiver. The spring is connected with the paper diaphragm of the transmittor by means of a silken thread, which is placed just sufficiently in tension to cause the outer face of the diaphragm to assume a slightly convex form. This apparatus is placed on the opposite side of the cylinder to the receiver. Having set the latter apparatus back from the cylinder, and having, by turning the handle in a reverse direction, set the cylinder back to what we may term the zero point, the transmitting

apparatus is advanced towards the cylinder, by means of a set screw, until the steel point rests without absolute pressure in the first indentation made by the point of the receiver. If now the handle be turned at the same speed as it was when the message was being recorded, the steel point will follow the line of impression, and will vibrate in periods corresponding to the impressions previously produced on the foil by the point of the receiving apparatus. Vibrations of the requisite number and depth being thus communicated to the paper diaphragm, there will be produced precisely the same sounds that in the first instance were required to produce the impressions formed on the tin-foil. Thus the words of the speaker will be heard issuing from the conical drum in his own voice, tinged, however, with a slight metallic or mechanical tone. If the cylinder be revolved more slowly than when the message was being recorded, the voice assumes a bass tone; if more quickly, the message is given with a childish treble. These variations occur according as the vibrations are more or less frequent.

Such is the apparatus, and it promises to be one of the most remarkable of the recent marvels of science. In using the machine for the purpose of correspondence, the metal strips are removed from the cylinder and sent to the person with whom the speaker desires to correspond, and who must possess a machine similar to that used by the sender. The person receiving the strips places them in turn on the cylinder of his apparatus, *applies the transmittor,* and puts the cylinder in motion, when he hears his friend's voice speaking to him from the indented metal. And he can repeat the contents of the missive as often as he pleases until he has worn the metal through. The sender can make an indefinite number of copies of his communication by taking a plaster of Paris cast of the original strip and rubbing off impressions from it on a clean sheet of foil. It will thus be seen, as we stated at the commencement of this article, that the voices of those who have left us, either for ever or for a season only, can be heard talking with us if we so desire it.—*Times.*

How the Phonograph came to be Invented.—An English patent of 1877, taken out by Mr. Edison, clearly shows that his mind was being prepared for the conception of the phonograph. In that patent he describes a means of recording ordinary telegraph signals by a chisel-shaped stylus indenting a sheet of paper, enveloping a cylinder or plate, along the line of a groove cut in the surface of the latter. These indented marks were to be capable of re-transmitting the message automatically over another wire if required. Here then was the soil prepared, and the vibrating disc of the telephone was the seed needful to germinate the phonograph. That seed was dropped into it by accident. "How did you discover the principle?" asked a newspaper reporter of Mr. Edison. "By the merest accident," replied the professor. "I was singing to the mouthpiece of a telephone, when the vibrations of the voice sent the fine steel point into my finger. That set

me to thinking. If I could record the actions of the point and send the point over the same surface afterward, I saw no reason why the thing should not talk. I tried the experiment first on a strip of telegraph paper, and found that the point made an alphabet. I shouted the words 'Halloo! halloo!' into the mouthpiece, ran the paper back over the steel point, and heard a faint 'Halloo! halloo!' in return. I determined to make a machine that would work accurately, and gave my assistants instructions, telling them what I had discovered. They laughed at me. That's the whole story. The machine came through the pricking of a finger."

The Microphone.—The wonders recorded of Aladdin's lamp must sink into insignificance when they are compared with the doings of that modern necromancer which we call Electricity. It instantaneously conveys our thoughts to distant places, it enables us to travel in safety by express speed by the warning which it flashes to the next stage that we are on the road. It helps us to blow up our enemies in time of war, or by the same apparatus to open up the treasures of the earth in more peaceful days. Our arts and manufactures are largely dependent upon it, the beacons that guide our sailors look to it for their light, and there is every reason to hope that our cities will soon be illumined by the same power. In fact, its uses seem to have no bounds, and, as week succeeds week, we hear of some fresh application of this universal agent to the service of mankind.

But electricity has lately appeared in a new character, as the obedient handmaid of sound. Although the connection between the two was to a certain extent known some years ago, it was reserved for Professor Graham Bell to point out how close this connection is, by his wonderful discovery of the telephone, which bears his name. This telephone has been so often described that it is perhaps more familiar to the general reader than many far more common but less interesting instruments. But its extreme sensitiveness, as a detector of sounds which we hardly knew to exist, was not guessed at until Professor Hughes announced a new instrument to the world under the title of "The. Microphone."

Professor Hughes was led to his wonderful discovery by experiments carried out by means of Bell's telephone; and in acknowledging the talent which he has brought to bear on his researches, we must not forget that they have been made manifest by means of that instrument. In short, we may say that "honours are divided."

We must remind our readers that in the telephone the electric current is induced by the action of a magnet on a coil of copper wire placed round it, an iron diaphragm set in motion by the speaker's voice causing variations in the current, which variations are faithfully carried to the distant telephone, where they are again translated into sound by means of a duplicate diaphragm. The toy telephone (sold in the streets for the past twenty years)

told us that a vibrating disc was capable of reproducing speech; and Bell's telephone suggested the means of transmitting such vibrations to any distance. It must be also remembered that the telephone is self-contained, in that it is quite independent of battery power.

But Professor Hughes was led by his experiments to place a small electric battery in circuit with the telephone; and the results were very curious. In the first place he found, by adding weights to a fine wire through which the current was flowing, that just before the breaking strain was reached—just when the fibres of the metal were torn asunder — a peculiar rushing sound was observable in the telephone. He then tried whether he could reproduce this noise by loosely binding the wires again together, and he found that by this means he had hit upon a wonderfully sensitive detector of sounds. Any noise near the wires was immediately taken up by the telephone with startling distinctness. The slightest attachment of the wires procured him the same results, and he modified the joined wires into an apparatus which merely consisted of three nails, two being parallel and connected with the battery wires, and the third resting upon them.

Although this ridiculously simple arrangement is capable of transmitting all kinds of noises to a distant place, the sounds obtained are very confused. Professor Hughes thereupon began to extend his experiments with different conducting substances. *He found to his surprise* that nearly everything he could hit upon responded in this marvellous manner to minute vibrations, but that various forms of carbon gave the most reliable results. An arrangement was devised which leaves little to be desired; indeed, we may say that it is so sensitive as to be almost beyond control. It consists of a tiny pencil of fine gas coke (such as is used for the electric lamp) dropped into indentations in two blocks of the same material. This compact little instrument, fastened to a cigar box, will transmit to a long distance the ticking of a watch placed near it. The gentle touch of a feather, or a camel's-hair pencil, reaches the ear as the rasping of a file, while the scratch of a quill pen in the act of writing is augmented to a loud noise. It will be seen therefore that the microphone not only detects sounds which without it are inaudible, but it also magnifies them.

The most recent and perfect form of microphone consists of a base board about three inches long, upon which are screwed two little angle pieces of brass plate. A metallic bar, pivoted on to these brass supports, has at its end a piece of carbon. This carbon block rests upon two similar pieces kept together by a cloth hinge placed at the side. The lower block, to which one of the battery wires is attached, is fastened to the board. The pressure upon these carbon surfaces is controlled by a delicate spring of brass wire, which is attached to a screw with a milled head. By turning this screw the pressure can be nicely adjusted, from the

very light contact required for delicate sounds to the comparatively heavy pressure wanted when the sounds are more intense. The carbon used in this form of microphone is pine charcoal, which has been subjected, in a suitable receptacle, to a white heat—a mode of treatment which seems to confer upon it properties of great value for the present purpose. Breathing, speaking, and singing are transmitted by this instrument with great fidelity, while the tramp of a fly is most distinctly audible.

It has again and again been proved that the most astonishing scientific discoveries have been made by means of the roughest apparatus. At the Loan Exhibition at South Kensington we had an opportunity of verifying this for ourselves, for there we saw the pasteboard tube, and rough glass lens, ground by himself, which served Galileo for a telescope; the bits of glass tubing, doctors' phials, and odds and ends which guided Dalton to the great atomic theory. And no doubt, if the thing had not been of a perishable nature, we should have found there the apple which hinted to Sir Isaac Newton the secret of gravitation. The instruments devised by the inventor of the microphone are no exception to the rule; indeed, it would seem as if Professor Hughes had taken a pride in showing what can be done by very simple means. A few nails, some sealing-wax, one or two bits of carbon, a penny money-box, and, finally, a prison for his flies, in the shape of a common match-box, with a muslin-covered hole in it for a window. With these simple materials he has constructed what is perhaps the most marvellous instrument of modern times.

We learn from the *Halifax Guardian* that the microphone was lately attached to the pulpit of a chapel in that town, the connecting wires being carried to a house more than a mile distant. Every word of the service was plainly transmitted through the wires, and "so faithfully did the instrument do its work, that the chapel-keeper was heard to close the doors after service, walk up the aisle, and up the pulpit-steps in conversation with some one else." This story, which we have no reason to doubt, will show the marvellous power of the tiny apparatus. But its first really practical application has been in the surgeon's hands, as a detector of foreign bodies, such as bullets, &c. It will also, no doubt, in great measure supersede the stethoscope in the diagnosis of lung and heart disease.

The microphone probably represents the first step on the border-land of a new science. It has revealed to us the undoubted fact that the inanimate things around us vibrate in sympathy with every movement we make, and with every sound that proceeds from our lips. The time may not be far distant when it will be possible to obtain an automatic record in plain black and white of every word we utter—a recording angel who will have no tears to blot out those words we might wish forgotten or unsaid.—*Graphic.*

The Microphone in Medical Practice.—After the invention

of the microphone it was natural to think of applying it to detect obscure sounds in the human body. But the efforts in this direction were not at first very successful. M. Du Moncel however announced, at a recent Meeting of the Paris Academy, that the problem had been solved by M. Ducretet, who employed in his "stethoscopic microphone" the very sensitive tambours of M. Marey. The only drawback to the apparatus is that it is rather too delicate in its action, and transmits to the ear a host of sounds, whose existence was not suspected, and the causes of which need investigation. This new instrument should greatly facilitate the work of medical men.

Seeing Sounds.—The year 1878 was so prolific of acoustical discoveries that we cannot feel much surprise that an instrument was devised for *seeing* sounds. It is aptly called the "Phoneidoscope," and is of extreme simplicity. It consists of two pieces of brass piping, which are joined in the form of the letter T placed sideways. One of the three openings is closed by the mahogany board which forms the base of the instrument. The upper opening is provided with a flat flange, upon which a ring of metal holding a soap film can be placed. The remaining orifice is furnished with an indiarubber tube, terminating in a mouthpiece of the common speaking-tube pattern. Upon singing or talking into this mouthpiece the delicate film of soap is thrown into visible vibration. It describes, by reflected light, the most beautiful patterns in all the colours of the rainbow—patterns which will remain constant for one note—but which go through many changes as the scale is sung through the tube. The quality or *timbre* of the sounds examined also has a marked influence upon the pattern produced. The mixture for making the film is a compound of Castile soap, water, and glycerine. It is of such tenacity that bubbles may be blown with it of Brobdingnagian dimensions. Patterns in sand, on vibrating discs of metal, were long ago produced by Chaldni, and Lissajous has also shown how sound can be translated into regular forms by means of tiny mirrors fastened to the bodies in vibration. But the phoneidoscope answers to far more delicate sounds than those dealt with by the two philosophers named, and the results achieved are far more beautiful in character.

X.—ELECTRICITY AND MAGNETISM.

Aluminium in Telegraphy.—The value of aluminium in telegraphy has before now attracted notice. This metal has double the conducting power of iron, and can be made into extremely thin wires. The high price of the metal and the difficulty of large production are, of course, grave obstacles in the way. But, as is pointed out in the *D. Allg. Pol. Zeitung*, it can easily be produced in quantities sufficient to give an alloy with iron suitable for use as telegraph wire, thinner and better conducting than the ordinary wire. Owing to its light weight such wire is specially fitted for military telegraphy, since great lengths can be carried on one bobbin. With regard to the production of aluminium, the tolerably abundant cryolite found in Greenland might furnish the raw material, and a reduction of it in smelting works, by means of silicious iron or zinc ore, might be practicable.—*English Mechanic.*

Engraving on Glass by Electricity.—A method of engraving on glass, which appears to be simple of application, is described by M. Planté, in January, 1878, in the *Annales de Chimie* (t. xiii., p. 143). A plate of glass is placed horizontally on a table, and a concentrated solution of potassium nitrate poured over its surface so as to form a thin layer. Of the two platinum terminals of a Planté secondary battery of 50 or 60 cells, one is immersed in the layer of liquid which covers the plate, along the edge of the plate; the other terminal is enclosed, except at its extremity, in an insulating-sheath. The operator, holding the latter in his hand, touches the glass covered with the saline solution at the points where he wishes to engrave characters or a design. Aluminous trail follows the electrode, and, however quickly it moves, the strokes made are neatly engraved on the glass. If the writing or drawing be done slowly, the strokes will be deeply engraved; their breadth will depend on the diameter of the wire serving as electrode; if it be pointed the strokes can be made extremely fine. Any other source of electricity may be employed instead of the secondary battery, provided the quantity and tension be sufficient—either an ordinary galvanic battery of a sufficient number of cells, or a Gramme machine, or even a magneto-electric machine with currents alternately positive and negative.

The Earth's Magnetic Force.—Captain F. J. Evans, hydrographer to the Admiralty, read a paper before the Geographical Society during the course of March, 1878, "On the Distribution of the Earth's Magnetic Force at the Present Time." The paper gave a historical sketch of the invention and improvements

of the mariner's compass, and noted the discoveries which that instrument had made of the action of the magnetic forces in different parts of the earth. The lecturer connected the phenomena thus brought to light with the variations of the compass, a due regard to which was absolutely necessary for safe navigation. In one region of the globe—the smaller—this variation was westerly, and in the other—the larger—it was easterly. Westerly a variation prevailed in the Atlantic and Indian Oceans, and easterly in the Pacific Ocean. As a matter of fact, the magnetic condition of the globe was always varying, but in what manner and to what end was absolutely unknown. Auroras and earth currents were then discussed, and notice was taken of the magnetic discoveries made during the voyage of the *Challenger*. Having marshalled the various facts and hypotheses concerning magnetic phenomena, the lecturer, in conclusion, said: "Such are the facts, and how are we to interpret them? Whichever way we look at the subject of the earth's magnetism and its secular changes, we find marvellous complexity and mystery; lapse of time and increase of knowledge appear to have thrown us farther and farther back in the solution. The terrella of Halley, the revolving poles of Hansteen, and the more recent hypothesis of the ablest men of the day, all fail to solve the mystery."

Earth Currents due to Terrestrial Magnetism. — A very simple experimental arrangement, due to Professor Leroy Broun, for exhibiting the action of the currents of electricity which pass round the earth, is described in Silliman's *American Journal* for May, 1878. (*See* also *Phil. Mag.*, June, p. 475). A coil of insulated copper wire was wound round a rectangular frame of wood, the sides of which were about 40 and 30 inches respectively. The extremities of the wire projected a short distance from one of the shorter sides of the frame. This frame was then so suspended in a horizontal position by wires attached to an ordinary hydrostatic balance (the beam of which moved in the plane of the magnetic meridian) that the longer sides were at right angles with the beam—that is, magnetic east and west. By adjusting weights in the pans the index of the balance was brought to zero. The projecting terminals of the coil dipped into mercury cups which could be connected with a battery. When the current from the battery passed round the rectangle from east to west on the northern side, and from west to east on the southern side, by the theory of terrestrial magnetism the northern side of the rectangle would be attracted and the southern side repelled; and that this was so, the corresponding deflection of the balance rendered visible. When the current was reversed the deflection was in the opposite direction. By breaking and closing the circuit at the proper intervals, to augment the oscillations, the large frame was readily made to oscillate through an arc of five degrees. By using (the author remarks) a rectangle containing a larger number of coils of wire attached to a very delicate balance and a con-

stantly-acting battery, the variation in the magnetism of the earth might thus be advantageously observed.

Improvements in Telegraphy.—A paper was read before the Dublin Meeting of the British Association, by Mr. Preece, on improvements in telegraphy. Its object was to vindicate the telegraph department from the reproach sometimes cast upon it of having originated no improvement since it became connected with the State. He gave a minute account of the various apparatus which have been in use for receiving messages by sight or sound—the former being indispensable when fast telegraphing is required, and the latter best adapted for ordinary use; and enumerated the various modifications which have been made in them in order to render the transmission of messages more rapid and efficient, and obviate the special difficulties which arise from the cloudy and humid atmosphere of England. By a recent improvement the rate of speed between England and Ireland has been increased 100 per cent.

Some of the inventions tried years ago fell into disuse because they were premature, but there is now an increased demand owing to the lowering of the scale. Giutl in 1853 invented a mode of sending two messages in opposite directions on the same line. In 1872 Mr. J. B. Stearns, in America, removed a defect in it, and there were now nearly 200 circuits in England worked on the duplex system. In 1855 it was discovered that two messages could be sent in the same direction, and hence duplex telegraphy was introduced. The two plans being combined formed quadruplex telegraphy. It was first used by the Western Union Telegraph Company in America, in 1876, and is now applied to 60 circuit telephone currents (verbal telegraphy), which are minute currents following each other with great rapidity on to superposed or ordinary working currents without interfering with their action as ordinary telegraph apparatus. Mr. Cromwell Varley utilized the principle in 1870, by patenting what may be called harmonic telegraphy; but it remained for Mr. Elisha Grey, of Chicago, to work it out practically.

Other systems for increasing the capacity of the wires have been devised on the Continent. The most valuable of all are the Wheatstone automatic and the quadruplex, but each has its disadvantages—principally the employment of a more highly-trained staff. Now, these systems of fast speed and multiplex telegraphy have grown up in England under the fostering care of the Post Office, since the transfer of the telegraphs to the State, and England stands prominent as the home of the inventor. She can boast of her Wheatstone, Cooke, Bain, Thomson, Clarke, Varley, Fuller, and others; and Europe can boast of Giutl, Siemens, Frischen, and Meyer; and America has her Morse, Hughes, Stearns, Edison, and Grey. The Americans have freely adopted the English system of pneumatic telegraphy and methods of testing. They are introducing on some lines automatic telegraphy, modified by

Messrs. Little and Edison, and are trying our superior batteries. Hence, while we have not been slow to avail ourselves of their advance, they have equally availed themselves of our progress. Invention has not left the shores of England, and the telegraph department stands in the front rank.

It remains to say a few words for the Post Office. The system of news wires is unique of its kind. Forty-seven news circuits and 22 special wires were made up every day. News is transmitted direct from London to every town where there is a daily paper. This is done by the automatic principle (mechanical transmission). Half a million words are frequently sent in one night from London. When Lord Beaconsfield gave his address in the House of Lords, on the results of the Berlin Congress, 526,250 words were transmitted from the central station. There is not a branch of the service that has not been improved. New batteries, new insulators, improved wires, the most perfect relays and multiplex apparatus haveall found their way into the Post Office service. Of the 8,000 miles of additional wire put up more than half is for private use, so that the daily average of messages is even greater than has been stated. No one is heard to complain but some disappointed inventor. Practical inventions rarely emanate from without, but the great majority of patents are taken out by persons who do not possess them at all. The fact remains that telegraphy is more highly developed in England than in any other country.

Agricultural Use of Electricity.—Berthelot recommends Grandeau's remarks upon the "influence of atmospheric electricity upon the nutrition of plants," referring especially to his discovery that the proportion of nitrogenous matter, which is formed under that influence in tobacco and maize, is twice the proportion which is found in the same plants when withdrawn from the influence of atmospheric electricity, the total growth of the plant being proportional to the nitrogenous matter. He also calls attention to some of his own investigations, especially to the fact that free nitrogen is accumulated by organic matters, not only by employing the strong intermittent tensions of ordinary induction apparatus, but also with very feeble and continuous tensions, and especially by employing atmospheric electricity. In some of his experiments microscopic vegetables appeared which absorbed an additional amount of nitrogen. Before his researches were undertaken it was generally supposed that nitric and nitrous acids and their ammoniacal salts were produced only by the electricity of heavy thunder showers. It is now evident that the reactions between vegetables and the atmosphere, under feeble electric tensions, are the most important, the smallness of the effects being compensated by their duration, and by the extent of the surfaces influenced.

The Telephone.—*See* "Sound," Section IX.

The Microphone.—*See* "Sound," Section IX.

The Electric Light. — *See* "Illuminating and Heating," Section XVI.

XI.—CHEMISTRY.

Breathing Carbonic Acid.—The dangerous properties of carbonic oxide have long been known. An atmosphere which contains only a little of this gas may produce poisoning and death. Some exact experiments on this subject have lately been described to the French Academy by M. Grehant. He concludes that a man or one of the lower animals compelled to breathe for half an hour in an atmosphere containing only $\frac{1}{779}$ of carbonic oxide, absorbs the gas in such quantity that about one-half of the red blood corpuscles combine with the gas and become incapable of absorbing oxygen; in an atmosphere containing $\frac{1}{1449}$ of carbonic oxide, about a fourth of the red corpuscles combine with this gas. These are important results both for physiology and hygiene.

Phosphorescence and Fluorescence.—Favé attributes both of these phenomena to "the reciprocal action of material vibrations and ethereal waves." Even ordinary phosphorus shines in a vacuum, in nitrogen, and in hydrogen, when there is no evidence of any chemical action. But when the phosphoric vapour reaches a certain density this light ceases. This furnishes one of the simplest examples of a vapour absorbing the waves which are produced by the same body when in a solid state. Such an extension of Kirchoff's law to solid bodies is confirmed by the nitrate of uranium, which gives eight brilliant phosphorescent lines, each corresponding to an absorption line, when a spectrum is made to traverse the salt,

Artificial Indigo.—Among the chemical papers read before the British Association at their Dublin meeting, by Prof. Emerson Reynolds, was an account of Prof. Baeyer's interesting experiments on the artificial production of the colouring principle of indigo. Hitherto we have only been able to produce artificially those colouring matters which lurk in the madder-root; no other vegetable dye has yielded to the chemist the secret of its constitution. Baeyer, however, has recently shown that it is possible to produce, by circuitous artificial means, the colouring matter which gives the beautiful blue to indigo. There seems, however, no chance at present of forming artificial indigo commercially, but the discovery is one of great interest to the man of science; for it is not often that we find ourselves able to build up compounds which are identical with the products of vegetable life.

The Restoration of Faded Handwriting.—In a paper on several interesting points connected with chemical technology (*Jour. prakt. Chem.*, 1878, xvii., 38), Von Bibra discusses the best means of rendering legible writing which, in process of time, has be-

come obscure. He refers to the custom of employing freshly-prepared ammonium hydrosulphate, which, he states, is to be applied with a brush, the excess to be removed by water, and the paper or parchment then quickly dried between folds of blotting-paper. In the case where an important document is to be deciphered, we cannot help regarding this as little else than heroic treatment, and prefer to pour the reagent in a watch-glass, and hold the manuscript over it, exposing it to the fumes of the strong hydrosulphate just so long as is necessary to develop the handwriting. At best the method is not a good one, because it converts the iron of the ink into the metallic sulphide which rapidly undergoes oxidation; the writing in a very short time will fade away, as the sulphate is diffused through the moist paper, and the characters will appear blurred when any subsequent attempt is made to revive them. Von Bibra has now found in a moderately-concentrated aqueous solution of tannin (gallotannic acid) an agent which produces the desired result, and at the same time possesses none of the disadvantages of the hydrosulphate. He applies the tannin solution with a brush, removes the excess by a current of water, and dries the document at a temperature of 50–60° R. The writing developed in this manner is clear and very black, remaining so after the lapse of several months. These methods, it need hardly be stated, refer only to manuscripts where ordinary ink has been employed, and not to documents written with Indian or carbon ink.

Spontaneous Ignition of Hydrogen in Air.—P. W. Hofmann has called attention to some curious cases where this gas has spontaneously ignited. The phenomenon has been noticed in factories where large quantities of zinc were being dissolved in hydrochloric acid for the preparation of zinc chloride. Violent explosions took place when no flame was nigh; and it was eventually ascertained that the gas took fire spontaneously. It appears to be caused by fragments of very porous zinc, which, when lifted above the surface of the liquid during the violent evolution of the gas, and so brought in contact with hydrogen and air, act just as spongy platinum would do under the circumstances. The author recommends the performance of such operations in the open air. The ignition can be shown by treating a few kilogrammes of finely-divided zinc with acid. The "zinc dust" may even ignite by contact with water (*Ind.-Blatt.*, xv., 105).

A Lecture Experiment Improved.—The ordinary method of igniting soap-bubbles filled with hydrogen, or oxygen and hydrogen, as they rise in the air, is open to some objections as a lecture experiment. M. Remsen, of the Berlin Chemical Society, improves on it thus:—At a height of 5ft. or 6ft. above the experimental table is suspended from the roof a large glass funnel in inverted position. A gas-burner is fixed in the middle of the lower part of the funnel, so that the flame when formed is in a horizontal plane. It is now only necessary to liberate the soap-bubbles somewhere about

vertically under the funnel. They come with certainty into contact with the flame. If they contain hydrogen the whole funnel is often filled with the flame. The experiment is easy, and without danger.

The Decomposition of Steam.—At a recent meeting of the American Academy of Sciences an apparatus was shown at work which proved that steam might be decomposed by simple heat into the constituent gases of water. The heat employed was a little over ordinary redness, but did not reach whiteness. The experiment is highly valuable, as indicating a possible cause of boiler explosions. The apparatus was very simple—a flask in which water was heated, a tube conveying the steam into a closed platinum crucible, where it was again heated by a spirit-lamp, and a tube thence carrying the superheated steam and the liberated gases to an ordinary pneumatic trough, where the mixed gases were collected in a test tube, while the steam was absorbed. At the end of the experiment the gases thus collected were exploded by a lighted match. This explosive mixture of gases may be formed in a steam-boiler, but only as the result of the most culpable carelessness. The boiler must—at least in part—be raised to a full red heat; then cold water must be injected, for so long as steam and the gases are mixed the latter cannot explode. The injection of water must condense the steam in the boiler before it cools the red-hot iron. All these conditions being fulfilled an explosion of the gases may take place.

Destruction of Leather by Gas.—An interesting note on this subject, by G. E. Davis, appeared in the *Chemical News*, xxxvi., 227. Mr. Davis examined the leather of some books which had been in daily use in a leading office in Manchester from 1855 to 1858; after that time till August, 1877, they remained uncovered on a shelf near the ceiling of the same room. The books were bound in rough calf, and had red basil lettering-pieces. When the books were roughly handled at the time the author saw them the leather of the backs came off as a mixture of dust and small pieces, which were very acid to test-paper. The leather of the back contained 2·847 per cent. combined sulphuric acid, and 1·920 per cent. of free sulphuric acid; the red basil lettering-piece contained 0·99 per cent. combined, and 0·87 per cent. free, acid; and the piece of leather covered by the lettering-piece contained 0·39 per cent. combined, and 0·76 per cent. free, sulphuric acid. The leather of another book was found to contain still larger quantities of acid, that in combination amounting to 3·46 per cent., the free acid being 2·18 per cent. of ammonia. A piece of leather from the side of this second book gave the following numbers: ammonia, 0·46 per cent; sulphuric acid, in form of sulphate, 1·85 per cent.; and uncombined sulphuric acid, 0·64 per cent.

Estimation of Mineral Oil or Paraffin Wax in Mixture with other Oils or Fats.—Dr. William Thomson, F.R.S.E., read a paper on this subject at the Dublin Meeting of the British Association. He said that mixed oils were now often used for lubricating purposes, and a common

mixture, composed of mineral oil with some animal, vegetable, or fish oils, was now extensively used, and it was an important point to be able by analysis to determine the amount of mineral oil which such mixture contained, and as he could find no published process to effect this, he devised, after much work, the following, which he found by repeated tests to give very accurate results:—He boiled some of the sample with an alcoholic solution of caustic soda, which converted all the animal, vegetable, or fish oils into soap. This was then mixed with sand, and heated and washed with petroleum spirit, distilled at a temperature under 190° Fah. This dissolves out the mineral oil, leaving the soap insoluble. The spirit is now distilled off from the spirit solution of mineral oil, at a temperature not exceeding 220° Fah., and the residue of mineral oil weighed and calculated on the weight of the original mixed oil taken.—*Iron.*

The Spectrum of Chloro-chromic Anhydride.—Mr. G. Johnstone Stoney communicated to the Dublin Meeting of the British Association the results of a long investigation by himself and Professor J. Emmerson Reynolds on the spectrum of chloro-chromic anhydride. He described the kinetic theory, which supposes that gases consist of molecules darting about and continually striking against each other, but, besides these, he said there were internal motions within the molecules, which in many cases were either periodic or quasi-periodic. The evidence of this was obtained from *the spectra* of gases. For years he had been engaged in searching for cases of harmonic motion in gas, and, with the assistance of Professor Reynolds, he had obtained the positions of 105 lines in the spectrum of chloro-chromic anhydride, which proved to be harmonics of one particular motion. Some idea might be formed of the rapidity and minuteness of these vibrations from the fact that in one gas 80,000,000,000, and in another 22,800,000,000,000, occurred in the course of a single second.

Differences of Chemical Structure and Digestion among Animals. — Mr. Hoppe-Seyler, a learned German, published a paper during the course of 1878, on Differences of Chemical Structure and of Digestion among Animals, supported by numerous examples, which show that according to the organism so is the power to form differences of tissue; and he sums up thus: "Looking at the question broadly, we find that the chemical composition of the tissues, and the chemical functions of the organs, present undoubted relations to the stages of development which show themselves in the zoological system, as well as in the early stages of development of each individual higher organism. These relations deserve further notice and investigation, and are qualified in many respects to prevent and correct errors in the classification of animals. It is generally supposed that the study of development is a purely morphological science, but it also presents a large field for chemical research." This concluding sentence is significant, and should have serious consideration.

The Liquefaction of the "Per-

manent" Gases.—In 1845 the late Professor Faraday delivered a lecture on the solidification of gases, at the Royal Institution, and demonstrated his facts by experiments as interesting as they were successful. Under his skilful manipulation a tube filled with olefiant gas, quite invisible, was seen to become partially filled with a colourless liquid, which was the gas in a condensed form. Two conditions were shown to be essential to the result—extreme pressure, and extreme cold. The pressure was obtained by strong mechanical appliances, and the cold by means of solidified carbonic acid, which looked like lumps of snow. In this way the lecturer made clear to a general audience the process by which a number of gases had been brought into a liquid or solid form; and he stated that he had "hoped to make oxygen the subject of the evening's experiment, but from some undetected cause it had baffled his attempts at solidification." Nevertheless, he looked forward to the time when not only oxygen, but azote and hydrogen would be solidified, and he agreed with Dumas, of the Institute of France, that hydrogen would show itself in the form of a metal.

Faraday's anticipations are now realised. The achievement of liquefying oxygen is due to the enlightened and persevering efforts of M. Pictet, an able physicist of Geneva. Working with apparatus capable of resisting a pressure of eight hundred atmospheres, and a temperature sixty-five degrees below zero (centrigade), he succeeded, in the close of 1877, in converting oxygen (invisible) into a visible liquid which spouted from the tube in which it had been inclosed for experiment. It is a feat which involves important consequences for science. It is a further confirmation of the mechanical theory of heat, according to which all gases are vapours capable of passing through the three states—solid, liquid, and gaseous.

Hydrogen and nitrogen next yielded to the physicist's power, and there is no longer, in our part of the universe, any such thing as a permanent gas. After Pictet, in Geneva, had led the way by liquefying oxygen, Cailletet followed in Paris with the other two; but Pictet afterwards went further, obtained liquid hydrogen in considerable quantity, and produced solid particles of oxygen.

M. Dumas, the distinguished chemist, in giving an account to a scientific society in Paris of the liquefaction and solidification of gases, stated that the specimen of oxygen produced by M. Pictet, of Geneva, was the size of a hen's egg, and resembled snow in the solid form, and water in the liquid form. Theoretically he had concluded that the density of liquid oxygen would be about the same as that of water; and this has been confirmed by experiment.

As regards hydrogen, M. Dumas explained that it was liquefied under a pressure of six hundred and fifty atmospheres, with cold minus one hundred and forty degrees; and by evaporating the liquid thus obtained, the solid condition, showing the colour of blue steel, was arrived at. Many years ago this possibility was foreseen, and the most advanced chemists admitted the existence of a theoretical metal—hydro-

XII.—WEIGHTS, MEASURES, AND TIME-KEEPERS.

A Hydro-pneumatic Clock.—A hydro-pneumatic clock, devised by M. Bourdon, has been reported on favourably to the French Society of Encouragement. The motor recalls, in some measure, the principle of the ancient clepsydras, and the means of communication between this organ and the clockwork movement is the circular tube with flattened elliptical section, which M. Bourdon has already used in various ways. The motive agent is essentially atmospheric pressure, acting by reason of a certain degree of vacuum produced by means of the trompe of laboratories (of improved form). A first reservoir may be filled at intervals; or it may be a cistern fed by rains or otherwise; in which case the flow may be considered as indefinite. This dispensing with the necessity of winding is one advantage, and should be specially useful in meteorological observations. Again, a single motor may, with ease, be arranged to actuate a number of clocks distributed throughout one edifice or in the neighbourhood, the tube from the trompe being made to give off branches.

Spiral Springs of Gold Alloy.—Hitherto, steel has been the metal chiefly used for making spiral springs for chronometers, &c. Its tendency to oxidation is a great disadvantage, as a mere speck of rust will suffice to affect the regulation of an instrument. At one time it was thought to remedy this by coating with unoxidable metal, such as gold, but the unlooked-for galvanic action upset this plan. Zinc was somewhat better, but had to be put on in considerable thickness, and this impaired the elasticity of the spring, Coats of varnish were open to a like objection, and others. Various metals were tried as a substitute for steel (hard platinum, silver, aluminium bronze, nickel, &c.), but gold alone seemed to promise favourable results. The earlier experimenters with this seem to have been rather unsuccessful, but (according to the *Journal Suisse d'Horlogerie*) spiral springs of gold alloy can now be made, which are in many ways superior to those of steel, and a greatly extended use of them for chronometers and other instruments of precision may be anticipated, especially at sea and on coast lines. Such spirals can be made so as to bear very high temperatures without deformation as they have to be made of greater thickness than the steel ones, their great weight makes them liable to a trembling motion through shocks. This, however, does not disturb the regulation, if care be taken to keep the windings somewhat apart from each other, and make the blade of the spiral of little height.—*English Mechanic.*

XIII.—DOMESTIC NEWS.

Paper Window-Shutters.—We owe the latest application of paper to the industrial arts to an American, who has recently patented an invention by which he proposes to utilize paper for the manufacture of inside blinds or shutters for windows. A shutter made of paper is claimed not to be so liable to be affected by shrinkage and expansion, and therefore to be free from the disadvantages of binding or open joints. It is said to be lighter and cheaper than wood, and it may be attached where wooden shutters cannot be. It admits of every variety of painting or ornamentation in set patterns ready for the trade, renewable at any time in similar manner to wall-paper. The shutter parts are composed of panels or sections united by flexible joint hinges of cloth. The strip of fabric is cut with tongues, two strips being glued one on each side of the same section, and the tongues of each strip lapping on the opposite sides of the adjacent section. These hinge strips extend from top to bottom. The panels thus joined are similarly hinged to jamb pieces for attachment to the jambs, which pieces are wide or narrow to suit different styles of windows, and are constructed with reference to the folding of the shutters. At the point of junction of the shutter parts, in the centre line of the window, they are provided with rabbets to close the joint and shut out the view, and to prevent the shutter from springing or warping. The jamb pieces can also be applied upon the surface of the architrave, where the jamb is too shallow to receive the wooden shutter now in use. This is claimed to be an important advantage, as it permits of the application of inside shutters to any house without alteration of the windows.—*Furniture Gazette.*

A Fan Worked by Machinery.—A novel instrument for producing a refreshing current of air in a room, capable of being used in a lady's hand, in lieu of the usual fan, has been devised by General Franzini. By means of clockwork in the handle, set in motion or stopped at will by pressing a button, an oval plate is caused to revolve. On its longer axis is an oval frame, in shape and size like that of the hand looking-glasses commonly in use. The revolving plate may be either a plain metallic sheet or a piece of plate looking-glass, and the frame is susceptible of any amount of ornament. The lady is thus saved the exertion of waving the fan in her hand. A similar instrument of a larger kind may be placed on a table, concealed, if desired, by a bouquet of flowers.

Special Flowers for Mourning.—These are now manufactured in Paris—artificial blossoms in an apparently withered condition.

Thus there are white roses with spots of decay near the heart, and the edges of the leaves curled and tinged with brown; sprays of dying tea roses and tiny worm-eaten buds hidden in russet dead leaves; faded pansies and dried-up violets, and purple and white heliotrope for those whose grief is not too deep for consolation.

How to Clean Waterpipes.—Cleaning small waterpipes by means of eels is the latest piece of transatlantic ingenuity. A hole being punched in the tail of a small eel, and a string inserted, the eel is put into the pipe, and speedily wriggles down to the other end, dragging after it the string, to which a bundle of rags is attached.

Parisian Novelties of 1878.—Parisian dandies now wear small hooks attached to their boots, to catch up the edge of their supernaturally wide-ankled trousers on rainy days, and keep them out of the mud. Yet another Parisian novelty is for the fairer sex, the "bouquet-bijou," which is to take the place of the knot of real flowers worn in front of the dress. It is a jewelled bouquet of roses, forget-me-nots, and lilies of the valley, the petals sprinkled with tiny diamonds to imitate dew, and the stalks held together by a diamond lizard.

Recreation and Playgrounds.—A paper on play and playgrounds was read by Dr. Joseph Pope before the Domestic Economy Congress, at its Meeting at Manchester, in June, 1878. In it the author said he would like to see a playground attached to every school, and one properly furnished—not mere bare walls and gravel. Owing to the pressure brought upon them, the London School Board had thrown open their playgrounds to children who lived in the neighbourhood, but the Board would not furnish playgrounds without aid from the public. He advocated perfect freedom for the child in play, and ridiculed the daily short and solemn walk of girls' schools, which was often the only means of recreation of these young ladies.

The Method of Teaching Domestic Economy in Schools.—In a paper on this subject, read before the Domestic Economy Congress of 1878, the Rev. T. Graham argued that an attempt should be made to give the subject something of a scientific character. Most of the problems of domestic economy fell, directly or indirectly, under chemistry or animal physiology in their application to common life. With a view to a scientific arrangement of the subjects included under domestic economy, a triple course, such as the following, might be proposed:—1, a preliminary course of instruction in chemistry, as much at least as was needed to lay the foundation of a scientific knowledge of domestic economy; 2, an intermediate course of instruction in animal physiology; 3, a final course, the application of the two preceding ones to the phenomena of household life.

XIV.—OUR FOOD SUPPLIES.

The Preservation of Fish.—Mr. Johannes Eckart, of Munich, discovered in the course of 1878 a method of keeping fish perfectly fresh for many days after capture, his plan of procedure consisting in impregnating them by means of hydraulic pressure with a weak solution of salicylic acid, packing them in casks or cases, and pouring gelatine over them. The latter serves to prevent their becoming stiff and dry. Prepared and packed in the above manner, they may, it is said, remain ten to fifteen days, and even longer *en route*, without detriment to their flavour or appearance. As one of Mr. Eckart's patent impregnating machines, large enough to hold 400 lb. of fish, will prepare some 8,000 lb. per diem, a considerable amount of piscine produce can thus be quickly preserved for dispatch to any destination; and since ice is altogether dispensed with, and no necessity exists for sending the fish by fast trains, the cost of transport is of course greatly reduced.—*Fishing Gazette.*

Curiosities in Hen's Eggs.—The experiment of Harvey is well known, in which a hen's egg is uncovered on the third day of incubation. The beatings of the heart are perceived, but suddenly stop. The egg is then put in tepid water, and the heart begins to beat again. M. Dareste has lately gone a little further. He takes from the sitting hen an egg which has been three days under incubation, and keeps it at ordinary temperature for two or three days (of 24 hours). Then he replaces it in conditions favourable to incubation. The fowl is developed as usual. It appears from this experiment that the life of warm-blooded animals may be suspended for a very long time without death intervening, just as is the case with very inferior animals—*e.g.*, rotifers.

A New Species of Coffee.—The prejudices and practices of coffee-planters are likely to be revolutionized by the discovery of a new species of coffee on the West Coast of Africa—the *Coffea Liberica*, or Liberian coffee—and its introduction into coffee growing countries. The transplantation of this plant from its native soil to Ceylon, Brazil, and other countries has been attended with such extraordinary results that the tree is likely in time to quite supersede the *Coffea Arabica*, the species now usually cultivated. Of little importance in its native country, the Liberian coffee becomes astonishingly productive when placed in the best plantations alongside or very close to its better-known rival; and it has this peculiarity—that whereas the Arabian coffee flourishes at an altitude of from 2,000ft. to 6,000ft. above the sea level, the Liberian variety thrives from the sea level to an elevation of 1,000ft. It is not certain, how-

ever, that it cannot be cultivated at a considerably greater altitude, in which case its value will be greatly enhanced. On an estate in Ceylon, where the African plant has been tested, the enormous crop of two tons of coffee to an acre has been yielded. The plant is being tested in several other countries besides Ceylon. In Brazil, Venezuela, South Australia, Guatemala, Queensland, Fiji, Jamaica, and other lands, the seeds have been planted or young trees introduced. It is curious that hitherto England has been the principal centre of its propagation. Large numbers of saplings and many thousands of seeds have been distributed from London, where the tree has been cultivated under artificial heat. The seeds travel well, if packed in damp moss. One important feature presented by the Liberian coffee is its power of resisting the leaf disease, which is so fatal to the planter's hopes in Ceylon; so far, at least, the plants grown in that colony have shown no signs of contracting the disease. There is little doubt that the Liberian coffee is destined to take a high place in the list of important vegetable products, and that it will be the means of introducing a valuable industry into countries which would otherwise not have thought of entering into competition with the coffee districts of South America and the East.—*Colonies and India.*

The Milk of the Cow-tree.—Nearly fifty years ago M. Boussingault, the eminent French chemist, made some interesting observations on the juice of the *Galactodendron*, commonly known as the "cow-tree." Some specimens of the plant exhibited in the Champs-de-Mars during the time of the Exhibition, enabled him to prosecute his study of this vegetable milk. The cow-tree grows to a height of 15 to 28 mètres; its leaves are oblong and alternate, and terminate in coriaceous points. The Indians "milk" the tree by making incisions in the trunk. The nutritive qualities of the milk are undoubted. M. Boussingault took it several months with coffee or chocolate. It is much more consistent than cows' milk, and has a weakly, acid reaction. In air it soon coagulates into a kind of cheese. This contains a complex fatty matter, melting at 50° C., very similar to bees'-wax, and of which the author made excellent candles. There is also present a nitrogenised matter similar to albumen or vegetable fibrine. The remainder consists of saccharine substances, salts of potash, lime, magnesia, phosphates, and water. It differs from cow's milk in its quantitative composition, and is like cream (the constituents being mainly butter, 35; sugar, 3; phosphates, casein, and albumen, 4; water, 58). M. Boussingault thinks the cow-tree might be usefully naturalised in Algeria; but adds that it would be less valuable on account of the milk than on that of the wax, which could be got from it in abundance.—*English Mechanic.*

Artificial Hatching.—The fact that a good hen will lay annually 120 to 150 eggs, while it can only hatch 30 or 32 of them, has led to many attempts at artificial hatching. According to MM. Grünhaldt, of Oberlösnitz - Radebeul,

near Dresden, the reason of the indifferent success of most of these efforts has been that while they have variously aimed at producing and regulating the required heat, they have not had regard to the mode of communication of this heat. In natural hatching the heat is transferred to the egg from above by close contact of the hen's body, and this is required by the structure of the egg, in which the germinal vesicle always floats at top, whatever the position of the egg. In view of this, Cantelo (in England) has successfully hatched eggs by means of glass plates put over them, and bathed with warm water. A further step is that of Baumeyer, who replaces the plates with tubes, through which warm water of 40° C. circulates. MM. Grünhaldt have worked on this system for several years, and variously improved it. They supply a small hatching apparatus, consisting of a small elegant chest for 72 eggs. It is heated with a smokeless petroleum lamp, and is furnished with an automatic regulator of heat, so that personal attendance is reduced to a minimum of 5 to 15 minutes daily. The price, without artificial mother, is about £7, with artificial mother, £10.

How to Keep Fresh Fish.—The flesh of fresh fish, either raw or boiled, should be cut in thin slices and plunged in a bath of water strongly acidulated with citric acid. After two or three hours' soaking the fish is removed and dried, either in the air or under moderate heat. In the latter case, one hour is sufficient; in the former there should be an exposure of five or six days. M. D'Amélio states that fish thus treated will keep anywhere for an indefinite period, and that it becomes as hard as wood. To prepare it for use, three or four days' soaking in fresh water is necessary.—*Scientific American.*

A New Way of Adulterating Milk.—Glycerine and water form the latest favourite method of adulterating milk, as by these the orthodox amount of solid—the absence of which ordinarily, as compared with pure milk, betrays the aqueous admixture—is thus restored. The fraud, however, has been detected by Dr. Munster, owing to the so-called pure milk not yielding the requisite amount of ash.

The Adulteration Act and the Milk-Sellers.—A paper on "The Adulteration Act in so far as it Relates to the Prosecution of Milk-Sellers," was read at the Dublin meeting of the British Association, by Mr. E. H. Cook. More prosecutions of milk-sellers have occurred than of any other vendors, and, he feared they must add, more unsatisfactory decisions were given than in other prosecutions. Instances had occurred in which innocent milk-sellers had been fined for selling a pure article, and in very many cases they might be sure the fraudulent dealer had gone unpunished. Milk was a substance which varied greatly in quality. As a result of four years' experience it appeared to him that milk was subject to four kinds of adulteration — a variation owing to the food, a variation owing to the season, a variation owing to the animal, and a variation owing to the health. The best milk was given by those

cows which were fed on grass, and the better the grass—other things being equal—the richer the milk. Grains largely increased the quantity, but diminished the quality of the article. That the quantity of milk yielded by the same cow varied at different seasons of the year was well known, and the quality also varied considerably. Generally speaking, milk was richer in summer, because the milk-producing articles were then available for food; but the variation with the season, he was inclined to think, was more due to the time of calving than to the alternation of summer and winter. Some cows gave better milk than others.

If, then, milk was subject to these natural variations how were they to decide upon its sophistication? By adopting as their standard of pure milk the lowest percentage of solids not fat which it had ever been found to contain. This was the principle which was adopted by most analysts, but was open to objections—one being the fact that by the Adulteration Act the analyst was to fix the percentage himself, and it varied. In order that justice might be done, fraud detected, and the dignity of the chemist maintained, it was necessary to remedy that unsatisfactory state of things. Only one method appeared to offer a chance of success. Briefly, that was to buy and sell milk by quality, instead of by quantity. One method of introducing the practice would be to divide the milk into two qualities—first and second—the former to include all milks containing 12 per cent. of solids, and 9 per cent. of solids not fat, and to be sold at, say, 4*d.* per quart; and the latter to include all milks containing less than 12 per cent. of solids, or 9 per cent. of solids not fat. The vendor thus selling according to quality no unjust prosecution would arise.

Dr. Cameron, city analyst, said he had made a special study of milk, and had analysed since 1862 many thousands of samples. He had never known a case in which the result of the mixed milk of a herd of cows had fallen below 11.5 per cent. He had made analyses of milk in hundreds of cases in which successful prosecutions had followed, and in all of which it was in the power of the person charged with the offence to have the milk analysed by the Somerset House analyst; but in no case had they elected to do so, which he looked on as an admission of their guilt. The great difficulty an analyst had to contend against was when the milk was poor in fats, or the deficiency might be attributed either to the milk having been skimmed, or to the first milk of the cow being sold instead of the whole milk. The milk first drawn from the cow was very poor in fats, whilst the last portion was rich in fats, and it was a common practice to sell the first milk as the whole milk, and the strippings, or the milk last drawn, as cream, or to keep the strippings to make butter. It was a more serious offence to sell, or offer for sale, skim milk as whole milk, than to sell watered milk, for the former was relatively destitute of the most valuable ingredient of milk—namely, the fats.

Artificial Butter.—Oleomar-

garine is coming very much into favour with the Americans, and the poorer classes greatly prefer it to ordinary butter. There are three manufactories in the States: at New York, Baltimore, and Philadelphia, and the compound was first sold in New York in December 1876, while by the 17th of February, 1878, so great was the demand that there were over 20 oleomargarine stores, all gaily ornamented with illuminated signs.

Lead in Aerated Water.—Some time since, Sir Robert Christison condemned the use of syphons for lemonade, owing to the action which free tartaric acid has upon lead, and the rapidity with which waters containing any free acid become charged with lead in syphons. According to Professor Miller, 0·0175 grain of lead per gallon is not an unusual amount for average cistern water. Mr. John S. Thompson, however, reports to the Edinburgh University Chemical Society that, after such water has been aërated, and put into a syphon, the amount of lead dissolved in it begins to rise in a rapid manner. Thus in potash water, drawn from a syphon, 0·0408 grain of lead per gallon were found to be present, being nearly 2·5 times the quantity found in the same water before it entered the syphon. Pure aërated water again drawn in a similar manner from a syphon, gave 0·0816 grain of lead per gallon, or exactly double the amount found in the potash water, showing at once the well-known protective action that salts of the alkalies and alkaline earths have on lead. Although, says the *Medical Journal*, these results are sufficiently high and alarming, still when the water is drawn off in small quantities at a time, as is frequently the case with invalids, the results are found to be still higher; thus when potash water was so treated, 0·0455 grain of lead per gallon were found, while aërated water, drawn off in small quantities, gave 0·0933 grain of lead per gallon, showing a very marked rise in both the cases experimented on.

XV.—MEDICAL.

On the Effect of Varnishing the Skin in Man.—When an animal, such as a dog or rabbit, is coated with an impermeable varnish, the temperature of its body falls, serious symptoms ensue and terminate in death. Suppression of the excretory functions of the skin is usually stated to be the cause, or at any rate one of the causes, of the phenomena in question. It is often assumed that similar results would follow varnishing in the human subject; and the assumption is supported by the old story of the boy who lost his life in consequence of being coated with gold-leaf, to represent an angel in a religious ceremony. Senator has put the question to the test of experiment (*Virchow's Archiv*, lxx., 182). Two healthy men allowed their limbs to be coated with impermeable plasters, while the trunk was varnished with several layers of flexible collodion. Nearly a week was allowed to elapse before these applications were removed. None of the evil consequences invariably observed in animals made their appearance; there was no fall of temperature, no albuminuria, no exhaustion, no dyspnœa, convulsion, or paralysis. Senator concludes that the gilded boy was probably poisoned by some ingredient in the material applied to his skin.

Ringing in the Ears Explained.—The phenomenon of ringing or tingling in the ears (*tinnitus aurium*) has recently been studied by Dr. Aigre. He believes that, in every case, it may be attributed to vibration of the walls of blood-vessels of the labyrinth. The vascular vibrations act on the terminal fibres of the auditory nerve, which they agitate. They may act on the nerve in two ways — either by increasing in amplitude, or simply by reflex action, by concentration, or by resonance. The former case occurs when there is increase or diminution of tension of the blood in the vessels of the labyrinth, or when the constitution of the blood is altered, as in chlorosis or anæmia.

Opium-eating in India.—In commenting on a paper by Mr. Richards, the *Medical Examiner* remarks that opium-eating, at any rate in Balasore, does not appear to cause either crime or insanity, for the inhabitants are a peaceable, law-abiding race, and the insane form only ·0069 per cent. of the population. Excessive use of opium may debase a man or make him a great sot, but never a raving maniac or a great criminal. Mr. Richards thus formulates the conclusion at which he arrived:—1. That opium is taken habitually by about 10 per cent. of the adult population of Balasore, and that the average daily allowance for a man is seven grains and for a woman five grains. 2. That moderation is the rule. 3. That

moderate doses include from two to sixteen grains per diem, according to circumstances. 4. That opium-eating is much more common in unhealthy localities than in healthy ones, even though they are situated in the same district. 5. That the drug may be, and is sometimes, taken in very large doses—thirty grains and upwards — without producing any very serious ill effect, much depending on the constitution, &c., of the individual and his habituation to its use. 6. That whatever the effects of the excessive use of the drug may be, when taken in moderation it is positively beneficial where such diseases as fever, elephantiasis, rheumatism, &c, are prevalent, and where food is scarce. 7. That the effects of even the most excessive use of opium are harmless, both to the individual and to society, compared with those of the excessive use of alcohol.

A New Mode of Dressing Wounds.—A new mode of dressing wounds, devised by Dr. Dughéne, of Gisors, consists essentially in the judicious use of pulverised vegetable charcoal to neutralise the deleterious effects of pus from the wound, as also of miasma or ferments from without, the introduction of which is further hindered by a superficial aromatic covering (bands impregnated with balsam). Dr. Dughéne has waited as long as 55 days before renewing such a dressing in the case of a comminuted fracture of the leg, with extensive injury of the fleshy part, and when the dressing was removed the wound was found almost completely cicatrised, while the bones were quite consolidated. He thinks the cure could have been accomplished without any renewal at all.

The Significance of the Cæcum.—Dr. Dureau (*Thèses de Paris*, 1877), the *British Medical Journal* tells us, discusses anew this subject by the light of comparative anatomy. The cæcum is rudimentary in man, carnivora, quadrumana, amphibia, insectivora &c.; in rodents, pachyderms, and ruminants, it is of capital importance. Among birds, it is similarly reduced to a simple tubercule among the rapacious birds (essentially carnivorous), and is prodigiously developed among the gallinaceous and certain of the palmipedes. Among herbivorous animals and birds, it appears to serve as a reservoir of elaboration and absorption of the food, its removal leading to extreme emaciation. In man and other carnivoræ, it does not seem to be of any use. It exists, one might say, as an anatomical protest against vegetarianism.

An Improvement in Anæsthesia.—An important discovery has recently been made by Professor Nussbaum, of Munich, which promises to ensure the ultimate triumph of chloroform. The new method has the great merit of retaining the patient in a conscious state while preventing him from feeling anything. The fact is not improbable that many of the fatal results which have followed the use of chloroform have been mainly produced by the dread which patients feel of becoming unconscious; but be that as it may, success has hitherto attended the new method in the hands of Pr-

fessor Thiersch, of Leipsic, and that circumstance is sufficient to ensure its thorough trial. The new system is based on the antagonistic action of drugs in the human economy. When the patient is ready, a subcutaneous injection of morphia is applied, and chloroform is immediately administered, the inhalation being continued for about five minutes, which is found to produce sufficient insensibility in the part for the operator to commence. The anodyne is subsequently administered at intervals to maintain the want of feeling, but is never employed to such an extent as to produce unconsciousness.—*Galignani.*

An Antidote to Mercury and Lead.—A prize of £400, founded in Belgium by Dr. Guinard, to reward any discovery tending materially to improve the material or intellectual condition of the working classes, has, by the jury, been unanimously awarded to M. Melsens, a member of the Belgian Academy. M. Melsens has discovered a method to counteract the poisonous effects produced either by emanations or by absorption of poisonous metals, or, rather, to prevent their deleterious effects. The agent he employs is iodide of potassium. Affections of this kind depend on the presence in the organs which are the seat of the malady of insoluble metallic compounds; iodide of potassium converts them into soluble metallic compounds, and expels them. For a long time iodide of potassium has been considered as a true poison. M. Melsens began by proving that the drug is inoffensive, on the essential condition of its being perfectly pure, and being administered in doses, at first small, and gradually increasing. The administration of very strong doses to persons poisoned would produce in the system a quantity of double soluble salt, sufficiently large when drawn into the circulation to cause real ordinary poisoning. The insoluble compounds of mercury, as well as those of lead, are easily transformed into soluble compounds by means of the alkaline iodides, and these soluble bodies are eliminated by the secretions of the body. The sulphate of lead, which is but little soluble in water, is, however, a poison fatal to animals, and it is as dangerous to handle as the carbonate of lead, and all the other insoluble compounds of this metal. All these bodies are eliminated by the action of iodide of potassium, which frees the system of them and prevents their deposit in the organs, when administered in suitable doses. M. Melsens has obtained a Montyon prize from the French Institute for the same discovery.

The Telegraph Cramp.—For a description of this complaint, which is chiefly confined to clerks who employ the Morse instrument, we are indebted to M. Onimus. The spasm or cramp, though seldom violent, is attended by the great inconvenience of preventing the signaller from co-ordinating the movements which alternately form lines and dots. Like all functional spasms, it is closely connected with individual temperament, the latter being usually of the nervous kind. The same remark applies to writers' cramp, and especially to bankers' clerks,

who are often compelled to write a number of letters rapidly, under fear of losing the post. All these cramps, which have a functional origin, have certain characters in common; they are sometimes observed in fiddlers, but in the signaller they are specially severe and frequent—a circumstance not to be wondered at if we remember that an ordinary clerk transmits about 7,000 signals per hour for seven or eight hours every day. If we add to the fear of committing errors of transmission the necessity of having the mind fixed during the receipt of a long despatch, it will not appear extraordinary that clerks are so often attacked by nervous derangement, which, fortunately, is confined to their fingers, though it may mount higher. Amongst female clerks the affection is much more frequent, and appears at an earlier date. It is often preceded by symptoms of general nervous disturbance, such as palpitation of the heart, dizziness, disturbed sleep, or even insomnia, and a peculiar feeling of constriction about the throat, which is probably a fragment of hysteria.—*Medical Examiner.*

Hydrophobia in France.—M. Proust, at a meeting of the Paris Academy of Medicine, held in November, 1877, read a paper on the results of the official inquiry into cases of hydrophobia observed in France from 1850 to 1876. Its conclusions were as follows:—1. Cauterisation being, up to the present time, the only means known as a prophylaxis against hydrophobia, it is important to obtain statistical information not only of the name of the caustic employed, but the manner in which the cauterisation was made, and the exact time which elapsed between the inoculation with rabies and the moment of cauterisation. 2. As the transmission of the contagium is often effected by little pet dogs, in which the disease at its outset inspires no mistrust, a memorandum with the object of popularising knowledge of the early symptoms of rabies would be of the greatest utility against this kind of contagion. The dog is not dangerous only when it has lost its reason; it is more treacherous whilst the sentiment of affection is still active, its saliva being already virulent. The widely spread opinion that canine rabies is always characterised by horror of water is untrue. 3. The sanitary police regulations applicable to canine rabies should be rigorously put into force in the winter as well as in the summer against suspected dogs, as much as against dogs actually in a state of disease. 4. The measures prescribed in these cases should be, the obligatory wearing of a collar, according to police regulation; the seizure of all stray dogs not wearing a collar; destruction of all the dogs so seized, and of diseased dogs; destruction or shutting up of all suspected dogs; also, in case of serious accidents or the death of a human being, the proprietor of the dog should be prosecuted by the authorities, without prejudice to any claim which may be made by the families of the injured persons.—*British Medical Journal.*

An Illusion Dispelled.—At a recent lecture held at the Rudol-

phinum, at Vienna, before a large audience, Dr. E. Lewy proved that the human skin is completely impenetrable for the chemical contact of mineral waters, and that therefore the explanation of the effects of baths in these waters at the numerous bathing-places has to be sought exclusively in the domain of physics, and not in that of chemistry. This important discovery annuls all common views regarding the bathing cures effected by the various mineral springs, and explains in the simplest manner that, from a chemical point of view, the action of the most opposite waters must be one and the same.—*Medical Press and Circular.*

Death by Drowning.—A series of experimental researches on death by submersion, and a number of *post-mortem* examinations on bodies found in the water and brought to the Paris Morgue, have furnished MM. Bergeron and Montano with a valuable collection of facts. Death by submersion may occur under very different conditions. The individual may fall into the water accidentally or may have been thrown there by an act of violence. This may have occurred during his sleep, whether natural or artificial, as in drunkenness or narcotism. The investigators reproduced experimentally some of these special conditions, as by narcotising animals with opium or chloroform, or rendering them motionless by curara, and then drowning them. They varied also, as much as possible, the special circumstances of submersion by more or less restraint of movement. The conclusions which they have reached are as follow:—1. The existence of a mucous foam, not only in the fauces and larynx, but also in the bronchi, is the constant sign of death by submersion, whether there was predominant syncope or asphyxia, whether the individual was free in his movements, or whether he was thrown into the water after being narcotised by chloroform or opium, half suffocated, or restrained in his movements. This constant presence of foam, whatever were the special circumstances in which the immersion took place, is, they maintain, the only constant sign of death by drowning. 2. There is always a certain amount of congestion, and there are sometimes subpleural ecchymoses; but these ecchymoses, which give to the lungs a mottled aspect (*aspect tigré*), never have the appearance of the punctate ecchymoses of suffocation. The sign given by Tardieu as characteristic of the latter form of death thus preserves all its value. 3. The intensity of the congestion and the extent of the ecchymoses are always in proportion to the struggles of the animal. It is the same with man, as the authors have verified by all the autopsies made at the Morgue during ten years. This fact has considerable medico-legal importance. The autopsy thus reveals something of what occurred during the last moments of life—whether the individual did or did not struggle energetically against the submersion.

The Theory of Sleep.—A. Strumpell (Pflüger's *Archiv*) reports the case of a patient, aged 16,

the whole of whose cutaneous surface was completely insensible, so that the strongest stimuli applied to the skin did not excite any expression of pain. A similar anæsthesia was shown in nearly all the accessible mucous membranes of the body, and muscular sensibility was completely wanting. In addition to this, there was a complete loss of smell and taste. Finally, the right eye was amaurotic, and the left ear deaf; so that, when the left eye was bound up and the right ear stopped, there was no further avenue of stimulus to the patient's brain. When the latter experiment was actually carried out, the patient in about five minutes sank into a deep sleep, from which he could only be roused by the stimulus to the ear or by the stimulus of light; he could not by shaking alone. When he was left to himself, he awoke in the course of the day, after many hours' sleep, either through internal stimuli or from the excitation of the brain through slight and unavoidable stimuli from without.—*British Medical Journal.*

The Hydrosphygmograph.—Under this name Mosso describes a modification of his well-known *plethysmograph*, designed to register momentary variations in the bulk of the human forearm, variations depending almost, if not quite, exclusively on alternate contraction and relaxation of the arterioles (*Comptes Rendus*, Février 25). The transition from intellectual repose to active exertion (as in attempting to solve a problem) causes instantaneous contraction of the blood-vessels in the arm, quickening of the heart's action, and increase in the volume of the brain (this was determined in three cases of accidental deficiency of part of the cranial walls). During deep sleep it was found that every stimulus — whether luminous, acoustic, or tactile—caused a very marked alteration in the character of the pulse, even when the impression on the sensorium was neither consciously perceived nor remembered. Local variations in the circulation, due to cold and heat, proved that dicrotism and polycrotism of the pulse are phenomena of local origin depending on the relative elasticity of the vascular walls. Lastly, temporary compression of the brachial artery and the application of Esmarch's elastic bandage were shown to cause a nutritive disturbance in the walls of the vessels.

A New Revulsive.—Dr. Couturiers (as reported by the *Medical Examiner*) recommends the use of a new revulsive obtained from an extract of red pepper. When rubbed up with any of the ordinary vehicles, and spread on thin paper, it is readily employed in the same manner as blistering paper. The action of this revulsive is rapid. The skin soon becomes reddish, warm, and the seat of a pricking sensation. These symptoms continue for about three hours, but never amount to anything resembling pain; nor does the action of the revulsive extend to the surrounding skin. It may, in fact, be compared to a sinapism continuing to act equably for twenty-four hours, after having produced a moiety of its usual effect. The red pepper revulsive is indicated in all cases where the

medical attendant desires to produce revulsion rapidly, and keep it up for a considerable time—in acute or chronic inflammation, for example, of the throat or bronchial tubes, in congestion of various organs, in rheumatic or neuralgic pains, &c. The patient will, of course, be cautioned against conveying any portion of the substance to the eyes or lips. When the paper has been removed the surface may be dusted with powdered starch, which at once arrests any feeling of heat or pricking that may remain.

Srawberries and Constipation.—Professor F. H. Storer, of Harvard University, in a communication to the *Journal of Pharmacy*, calls attention to the fact, not generally known (and which certainly would scarcely be expected), that ripe strawberries are very apt to induce constipation. He remarks that in the United States particularly, "where an immense and well-nigh universal consumption of this fruit is coincident with the setting in of hot weather, the constipating action of the berry is complicated, and, as it were, increased by the excessive waste of water from the body, by perspiration, which occurs at this period; and there can be little doubt that, taking the two causes together, the strawberry season—though perhaps beneficial to some constitutions—is the occasion of much ill-health among the American people."

An Artificial Larynx.—Dr. Foulis, of Glasgow, exhibited to the Medical Society of London, at a meeting during the month of January, 1878, a remarkable application by him of an artificial larynx. James Houston, a cloth-worker, 29 years of age, a native of Campsie, near Glasgow, had a malignant sarcomatous tumour in his larynx which obstructed respiration. It had twice been removed by opening the larynx and taking it out, but it had recurred, and from its malignant character would have produced death if the operation which Dr. Foulis described had not been performed. The larynx has been entirely taken out and an artificial one substituted. The patient was produced at the meeting of the Medical Society; he conversed with the members and read to the meeting a passage from the Prayer-book. The operation of removing the larynx was first performed by Billroth, of Vienna, in 1873, and the first attempt at supplying a new larynx was made for Billroth's patient by Gussenbour, whose original instrument was shown at the meeting. The instrument now worn by James Houston is an improvement of Gussenbour's by Dr. Irvine, of Glasgow. This is the first time the operation has been performed in Britain. It has been ten times tried on the Continent, with varying success. The present is the most successful case, the patient being in better health than he had experienced for many months. The deliberate and careful manner in which the operation was performed in this case probably accounts for the successful result. Care was taken to introduce a tube into the windpipe as soon as it was cut across, and below the seat of disease, so that no blood could get into the lungs during the further steps of

the operation. Dr. Foulis thus had ample time to thoroughly accomplish the removal of the larynx. The whole operation occupied two and a half hours, the patient being under the influence of chloroform. Recovery has been uninterrupted, and there is no appearance whatever of recurrence. The man is quite fit for light office work. The larynx supplied to him consists of two tubes, one of which goes downwards to the trachea and the other upwards to the mouth. The patient can talk in a whisper without these tubes, but when a reed-plate is slipped into a groove in the lower tube a resonant sound is produced which is modulated into letters and words by the mouth. The articulation with or without reeds is perfect. The reeds are made of metal, vulcanite, ivory, horn, &c., and the patient himself is fond of making reeds which give his voice new and surprising tones. The voice is a monotone, varying in *timbre* according to the reed used.

On the Secretion of Sweat.—A paper on this subject, by Adamkiewicz, was read before the Physiological Society of Berlin in the spring of 1878 (*His. and Dubois-Reymond's Archiv*, 1877, Heft. 6). The experiments were made on the human subject and on kittens. As regards the former, it was found that stimulation of a motor nerve (median, facial, &c.) was followed by an outbreak of perspiration over the muscles that had been thrown into contraction, and also upon the corresponding tract of skin on the opposite side of the body. The phenomenon was not influenced by previous arrest of the circulation through the part. Sweating of bilaterally symmetrical regions was also induced by stimulation of the sensory nerve-ends in the skin.

In the case of kittens, sweating of all four extremities was induced forty-five minutes after death by stimulation of the medulla oblongata. This result was obtained even after hemisection of the cord in the upper lumbar region. Faradisation of the central end of the brachial plexus caused sweating of the opposite paw, even after the spinal cord above the level of the third cervical vertabra and below the middle of the dorsal region had been completely destroyed. Stimulation of the central end of one sciatic was followed by sweating of the opposite hind paw, even after destruction of the cord as low down as the fourth lumbar vertebra. After complete removal of the lumbar cord together with the cauda equina, the hind paws may still be made to perspire by stimulating the central end of one brachial plexus. This no longer occurs when the lower end of the dorsal cord (up to the tenth dorsal vertebra) has likewise been removed. Stimulation of the lumbar cord induces perspiration in the hind paws even after the posterior roots of all the spinal nerves have been divided. This experiment may be successfully performed on a preparation consisting of only the lumbar portion of the spine, together with the lumbar cord, the hind legs, and the plexus of nerves connected with them.

The Physiology of Thirst.—An assistant-surgeon of the American army, during the early part of 1878,

made a very interesting report on the physiological effects of thirst, as observed in the experience of a troop of cavalry who ventured to pursue a band of Indians over the sandhills of Texas and lost their way. Under a burning sun, and marching over hot sand, they were four days without water. Even at the end of the first day many of the men were so exhausted that they fell from their horses, which were suffering apparently little less than their riders. During the three following days the mucous membrane of the mouth became so impaired that they could neither swallow nor perceive when anything was within their lips. Sugar, when placed in the mouth, remained like so much dry sand. Their voices became feeble and strange, and all became more or less deaf. Questions had to be repeated several times before they could be understood, the intellect of most of the men appearing to suffer, according to the report, though a difficulty of comprehension would no doubt arise from the imperfect utterance of tongues so terribly parched.

On one memorable occasion Mr. Stevenson, the engineer, records a moment of terrible excitement when he found himself absolutely unable to utter a sound. He found, he says, that saliva was as necessary for speech as a tongue. Vertigo and dimness of vision were experienced by all the company, and many became quite delirious. The lungs became so excessively dry, that the oxygenation of the blood was interrupted, and the whole party seemed to be in peril of suffocation. The fingers and palms were shrivelled, and in many cases the men's legs and feet were swollen. The details of the extremities to which they were driven are of a very revolting character, and ultimately their sufferings were enhanced by mental tortures, by suspicion of each other, and by persistent wakefulness. At the end of four days they obtained water, and, of course, found the temptation to drink irresistible. Water, however, quite failed to assuage their sufferings, and this medical reporter considers that their experience showed the sense of thirst to exist not in the stomach, but in the system generally. It could not be relieved until the remote tissues of the body had been reached. Copious draughts of water were at once ejected from the stomach, and warm coffee was the source of the greatest relief to them. It is a curious fact that, whereas all the horses suffered terribly, and many of them died under the ordeal, some mules they had with them were very little affected, and grazed at every halt with apparent unconcern.

Treatment for Consumptive Patients.—A correspondent of *Les Mondes*, during the course of 1878, called attention to the fact that butchers, though they may be pale and thin at entering on their work, quickly gain freshness of colour, stoutness, and a generally comfortable look. It is a pure hypothesis that they put aside the best portions of the meat for themselves, and it is a known fact that most of them lose appetite. The correspondent attributes their general well-being to assimilation, through the respiratory passages, of nutritive juices of the meat volatilised in the air

—a kind of nutrition by affusion. If this be so (it is argued) might not a system of hygienic treatment of chlorotic or anæmic young people (and especially children of a weak or lymphatic constitution) be based on it? M. le Moigno commends the idea, and offers one of his own for treatment of consumptive persons in place of sending them off to distant places with reputedly mild climates. In a well-ventilated, sunlit, and sheltered room, with southern exposure, he would, by means of a Mousseron brazier, the high moist heat of which is so salutary and favourable to respiration, form for the patient an artificial climate of Nice, having all the advantages, without the inconveniences, of the real climate. To aid the antiseptic action of the warm moist air, rich in vapours charged with dissolved carbonic acid, he would place in one or more corners of the room an open bottle of water saturated with sulphurous acid. By this arrangement he thinks the progress of the tuberculation would be arrested. It may here be mentioned that Dr. Blacher has recently reported (in the *Courrier Medical*) some excellent results from treatment of pulmonary consumption, in its first two periods, with glycerine instead of cod-liver oil (see *Les Mondes*, 15th August, 1878).

Respiration at High Altitudes.—At a meeting in April, 1878, of the Royal Society, Dr. William Marcet communicated a paper on "An experimental inquiry into the function of respiration at various altitudes." His experiments were mainly undertaken with the view of inquiry into the state of the respiration of tourists at various altitudes, and under the different circumstances met with on Alpine excursions. Pettenkofer's method was adopted in the estimation of carbonic acid, and the experiments were many in number. The ori-nasal mask worn to collect the air breathed out, and the indiarubber bags that received the breath, were described. Dr. Marcet confirmed previous experiments in the fact that the quantity of carbonic acid breathed out is greater after food has been taken, and in his experiments on respiration at high altitudes he endeavoured to neutralise the effect of food by taking an early breakfast and a late dinner, and doing the climbing between the meals. Experiments were made at the Breithorn, 13,685 ft.; St. Theodule, 10,899 ft.; the Riffel, 8,428 ft.; St. Bernard, 8,115 ft.; and the Lake of Geneva, 1,230 ft. In experiments made while sitting Dr. Marcet finds that there is an increase of carbonic acid breathed out as a person rises above the sea on a mountain excursion, and that this is due to the fall of the atmospheric temperature, and to the cold produced by increased evaporation from the body, arising from the diminished pressure of the atmosphere. In short, more carbonic acid is formed in the body to counterbalance the influence of cold from the causes just mentioned. If, on ascending to a higher level, we should find the same atmospheric temperature as we left at the lower station, still an increased amount of carbonic acid would be expected on account of the cold due to the greater cutaneous and pulmonary

evaporation. Dr. Marcet experimented in a similar manner while ascending hills. Walking up rapidly over rocks and grass-patches yields more carbonic acid, the amount being 3·155 grms. per minute, which, he said, was attended with the inhalation of the largest volume of air breathed. Ascending quickly at the height of St. Theodule caused a considerable elimination of carbonic acid through the lungs, amounting to 2·972 grms. On the other hand, walking leisurely up hill at the St. Barnard gave rise to the production of no more carbonic acid than quick walking on the level ground at that same station.

In Case of Drowning.—Dr. Howard, who is medical officer of the Harbour of New York, and who seems to have had a large experience in the management of persons taken from the water in a state of insensibility, gave an explanation and demonstration of his mode of treatment, in April, 1878, at the receiving house of the Royal Humane Society, in Hyde Park. The principles upon which he acts are, of course, the same which rule the well-known methods of Drs. Marshall Hall and Silvester—those of clearing away the water and mucus which prevent the entrance of air into the lungs, and the imitation of the movements of the chest in respiration. Dr. Howard first empties the stomach and passages as much as possible of water. For this he places the patient face downwards, puts a roll of something hard under the pit of the stomach, so that it is above the level of the mouth, and then presses with all his force on the back. Afterwards, to set up artificial breathing, instead of the partial rolling of the body or the pumping action of the arms now practised, the body is laid upon the back with the clothes stripped down to the waist. The pit of the stomach is now raised to the highest point by something under the back. A bundle of clothing or the body of another man will do for this. The head is thrown back, and the tongue must be drawn forward by an assistant, so as to keep open the entrance to the air tubes. The hands are passed above the head, the wrists crossed, and the arms kept firmly extended. In this position the chest is fully expanded. The surgeon, or operator, then kneels astride the body, places his hands on the lower part of the ribs, and steadily and gradually makes compression. Balancing on his knees he inclines himself forward till his face nearly touches that of the patient, and so lets fall the whole weight of his body upon the chest. When this has yielded as much as it will, he throws himself back by a sudden push to his first erect position of kneeling, and the elastic ribs by their expanding bellows action draw air into the lungs. These manœuvres must be repeated regularly some twelve or fifteen times in the minute. They are sometimes quickly successful, but may be continued for an hour or more with the hope of a good result. This proceeding is at any rate simple, and it has received the sanction of the New York Academy of Medicine.

XVI.—ILLUMINATING AND HEATING.

Illumination at Sea.—An important advance has been made towards solving the problem of illumination at sea by an adaptation of what is known as the Holmes's distress signal, in the form of a shot, for illuminating purposes, to be fired from mortars at ranges varying from five hundred to two thousand five hundred yards. These signals possess the remarkable property of emitting a very powerful white light the moment they come into contact with the water, and when once ignited are absolutely inextinguishable by either wind or water, and burn with a persistency that is almost incredible, thirty or forty minutes being an average duration. The shot containing this light is constructed so as to be buoyant upon the water, and, at the same time, with sufficient rigidity of form to withstand the concussion of the powder. Upon striking the water at the required range, the shot, floating up to the surface, immediately bursts into a brilliant flame with great illuminating power. Half-a-dozen of these shots fired from an ironclad or gunboat would effectually surround her with an impassable cordon of light at any required range, and by such a device the enemy's movements of attack would become plainly discernible, and any attempt to break through the illuminated zone of light be at once detected, however dark the night.

Reynier's Electric Lamp.—In reference to this lamp, M. de Parville makes the following observations in the *Bulletin Français*:—"With four Bunsen elements we have just seen a very pretty electric light produced. The elements, which can be charged in five minutes, may be stowed away in a corner, in the cellar, &c., and one may be certain of having, during three or four hours, a splendid, vivid, and at the same time—if it be sifted through a suitable globe —a soft and rosy light. This is evidently an important step taken in the difficult problem of the electrical illumination of apartments and small workshops." Let us give a brief description of the new system: When a platinum wire is interposed in the circuit of a battery, it may be sufficiently heated to emit a white light. If the wire be replaced by a thin rod of gas carbon, this also may be heated so as to produce a dazzling light. Such is the principle of the electric lamps acting by incandescence, of which various forms, more or less practical, were shown in Paris some years ago. A young electrical engineer, M. Reynier, has hit upon the idea of dispensing with all these complications, and of simply allowing the carbon to be consumed. The carbon, raised to a red-white heat by the electric current, is consumed by oxidation, like the wick of a lamp; but its cost is not so great as to pre-

vent its being replaced in the same manner. Thus is obtained an extremely simple electric lamp, which is managed with the same facility as an ordinary lamp. If much light is required, the wick is turned up—*i. e.*, the heated portion of carbon rod is augmented; if less light is needed, the wick is turned down. If the lamp is to be extinguished, the circuit is broken; if it is to be re-lit, a knob is turned, and the light flashes forth. Nothing can be simpler. The system is quite elementary. A rod, or rather a needle, of carbon, from twenty to thirty centimètres long, and from one to two millimètres thick, is held at one end by a metal rod, which tends to descend by its own weight, and at the other by a carbon wheel, in a vertical position. The carbon rod is pressed strongly, whatever may be the consumption of the material, against this wheel, which is made to turn slowly. The current raises the carbon to a white heat at the point of contact of the extremity of the rod with the carbon wheel. The expenditure for charcoal is about 10 centimes per hour. Thus, a rod costing 30 centimes (3d.) will last for three hours, and without any magneto-machine or steam-engine; but with a little battery of four to six elements anyone can have the electric light in his own home.—*Engineer.*

Electric Lighting.—The question of electrical illumination for streets passed in 1878 beyond the region of vague conjecture, for the system was established in Paris in the Avenue and Palace de l'Opera. The Jablochkoff *system there in use* was one of many which were represented in some form or another at the Exhibition, and, from the prominent attention it received, we may assume it to be one of the best.

The old plan of obtaining the electric light from battery power has long ago been discarded, except for lecture-room purposes, where such a light is only wanted occasionally—the expense and trouble being too great for more ordinary uses. Then came the invention of the magneto-electric machine, in which the electricity can be generated wholesale so long as the machine is kept in rapid motion. But here another element of expense comes upon the scene, in the shape of a steam-engine to furnish the requisite motive power. Moreover, one machine was only capable of feeding one light—in other words, the current could not be sub-divided and dealt with in detail, as in the case of gas. Another difficulty found in electric illumination was the necessarily complicated character of the lamp itself, or—as we should say in speaking of gas—the burner.

Our readers are no doubt aware that the actual light is obtained by furnishing the ends of the two wires from a source of electricity with pencils of carbon. The manner in which these carbons have until lately been placed is well known. They are attached to a box containing a clock movement—the complicated nature of which may be judged when we explain the conditions necessary to keep the light alive. In the first place, the upper carbon is consumed far more rapidly than the lower one, so that both must

be moved towards one another at different speeds in order that the actual light may be kept stationary. Moreover, in the event of the light ceasing to burn, the two points must be made to touch one another before the current can be re-established. The electric lamp, in fact, was until lately a most complicated and delicate piece of mechanism, and withal a very expensive one. But in June, of 1877, M. Jablochkoff brought forward his electric candle, which at once showed that there was a means of burning the electric light without a complicated lamp. (*See* The Year Book of Facts for 1877.)

The electric candle as now used in Paris is a simple affair. It consists of two pencils of compressed carbon placed side by side, instead of being one above the other, as in the older system. They are divided by a narrow strip of plaster of Paris, but connected at the top by a narrow bridge of carbon. The electric current is supplied to the two carbons, the circuit is completed by the connecting bridge, and a brilliant arc of light is established between them. The plaster partition is a non-conductor of electricity, therefore the two carbons are effectually insulated from one another throughout their lengths, but directly they begin to burn, the plaster in its incandescent state becomes a conductor at the point of fusion, and therefore the plaster and carbons burn down together like a veritable candle. The difficulty that will perhaps present itself to our readers, that one carbon would still be apt to consume more rapidly than the other, is got over by causing the machine which supplies the electricity to give an alternating current—*i.e.*, each candle is alternately positive and negative several times in a second—their rate of consumption being by this means exactly equalised.

One Jablochkoff candle of the size found most convenient in practice lasts for a little over two hours, but by an automatic shunt the burnt-out candle is immediately replaced by a fresh one. Each lamp—covered with an opal glass globe to correct the intense glare of the light—contains four candles, which one after the other are brought into circuit. The shunt consists of a bent lever somewhat like a common bell-crank. Its upper arm is furnished with a platinum wire which rests against the base of the carbon pencils. When the candle burns down to the place against which the wire leans, the arm falls over, as it has no longer any support. Its lower branch immediately makes electrical contact with the next candle; and the same operation is repeated as each pair of carbons becomes exhausted.

The possibility of electric illumination is now reduced to a question of pounds, shillings, and pence. The Strand was effectively lit up during the winter of 1878 by some electric lights contained in globes which were hung outside the Gaiety Theatre. The principle on which they were worked is known as the Lontin system.

It is evident, with so many workers in the field, that the day is not far distant when electric lighting will form an important industry. It cannot entirely super-

sede the use of gas, although in a great measure it must supplant it. Meanwhile the gas companies may take the wise precaution of reducing the price of that of which they have the monopoly, and people will not be too anxious to welcome their rival. That they can easily afford to do so is proved by their balance sheets, without entering into consideration of the fact that the by-products of their manufacture have lately become so valuable that little or no waste is left upon their hands.

The Lontin Electric Light.—So far as the illumination of open spaces, streets, and houses is concerned, the future, supposing gas to be to a certain extent superseded, appears to lie between the Lontin and the Jablockhoff light. The Siemens light has proved of great value for the purposes of lighthouses, where great intensity is desired. For ordinary uses, however, the problem is to moderate, not to increase, the intensity of the light. The Jablockhoff and Lontin lights have many points in common. The points of importance in each are the generation of the electricity by a machine, the distribution of the current, and the supply and regulation of the "candles." To the Jablochkoff lights the electrical force required is supplied by a gramme electrical machine. The Lontin light is worked by a machine invented by M. Lontin himself. It produces at will a unique current or multiple currents, direct currents, and inverted currents. These can be distributed on several circuits. A great *advantage in* distribution is thus obtained. The machine produces several focuses of light, which can be entirely independent of one another. With a single machine 36 lights have already been produced. The motive force employed to produce a light equal to 100 Carcel burners is half a horse power. A Carcel burner is a conventional measure, the standard of which is a Carcel lamp burning 42 grammes of purified colza oil in an hour. The electric force having been produced by the Lontin machine is conducted towards the "candles." In 1813 Sir Humphry Davy took two hot coals, put them in contact, and made a voltaic current pass through them. He then slightly separated them, and saw between them a bow of fire, which he called the electric arc. The "candles" of the Jablochkoff and Lontin lights are sticks of carbon representing the coal used by Sir Humphry Davy. M. Jablochkoff employs koalin in addition to carbon in a very ingenious manner, but the main superiority which the modern manufacturers of electric lights have over Sir Humphry Davy is in the superior economy with which electric force is now elicited. The carbons are vertically placed, one above the other, in the Lontin light as in that of M. Jablochkoff. The light comes not only from the electric arc between them, but also from the carbon candles themselves, which become incandescent and are consumed. A clock-work regulator advances them as they waste away, and it is stated that to such perfection has this contrivance been brought that, for a week or more, the lights at the Gaiety mentioned on p. 125 required no

adjustment during the four hours for which they burned every night. Having once been set, the regulator each night advanced the points without any aid whatever. At Paris little accidents are not unfrequent with the electric light. The Avenue de l'Opera is occasionally left in sudden darkness by some *contretemps*, and anything which renders this result unlikely to happen is, of course, an improvement. A Lontin light exhibited in experiments at the Paris Exhibition has remained luminous for 21 hours. The Lontin regulator and the Lontin machine are, it will have been seen, the speciality of this invention.

The advantages which this, like the other systems of electric lighting, possesses over gas, have been summarized as follows:—Gas emits a fetid odour; the electric light is without smell. Gas may occasion explosions and fires; the repairing of the pipes is often difficult; great heat is developed together with the light; the flame is always coloured even when gas has been completely purified. In the transmission of the electric light the pipes are replaced by wires; the voltaic arc diffuses very little heat (the hand may be held with impunity 12 inches above the Gaiety lamps), and the light attained is white, perfectly compounded of all the colours in the spectrum, like sunlight. Indeed, it is so white that spinners and dyers can utilize it for sampling their stuffs. It may be added that the appearance of the lamps when sufficiently roughened glass is used is very beautiful.

More about Electric Lighting.—Mr. Jamin, of the Academy of Sciences, Paris, has embodied in a paper on this subject many particulars of interest to general readers. The Gramme machine, he says, and the Jablochkoff candle have made the application of electricity to purposes of illumination, a fact beyond doubt. The carbon-points of a powerful machine are equal to the sun in lustre. It is even possible that this limit may be overpassed, for our sun does not occupy the first position in the universe. It is a star already old, the cooling of which is much advanced, and whose yellowish light begins to approach that of terrestrial flames.

In quantity and quality the electric light greatly exceeds all flames; and it is precisely this immense profusion of illuminating power that is regarded as objectionable. But nothing is easier than to reduce the lustre of the light to any degree that may be desired; it is only necessary to cover the arc with a large opalescent globe. This, while hiding the light, receives all the rays, and disperses them in the same way as if the globe itself were luminous.

A light, to be applicable for purposes of illumination, should contain the seven primitive colours of the spectrum in certain proportions. The flames of oil and gas do not contain the true proportions, which is the cause of their inferiority. The light from the carbons of the electric light is white—absolutely the same as that of the sun—and contains all the simple rays in the same proportions. It is complete and perfect, and replaces daylight without any modification. It is not the

same with the arc itself, which is violet blue, and gives to electric illumination the blueish tint which has been objected to with reason. But it is a fault of excess, which can be remedied, for while the missing rays cannot be added to gaslight, the superfluous rays can be removed from the electric light. Uranium glass and many other substances furnish the means of suppression. This suppression is necessary in other respects, for the objectionable rays are said to attack the humours of the eye and to be the origin of grave diseases.

In ordinary combustion a large amount of heat is produced, and noxious products are thrown off; but the electric light does not vitiate the atmosphere, and makes very little heat, which every one will recognise as important merits.

The conditions of good electrical lighting must be determined by a study of the general illumination of objects during the day. When the sky is clouded, the sunlight pierces the clouds as through a ground glass, and the whole sky is like an immense illuminated ceiling, radiating light from every point and in all directions. The objects illuminated diffuse in their turn the light which they receive, so that there is an intercrossing of rays, producing the effect of a mean amount of light everywhere: this is *general illumination*, and is the model that must be followed. The ceilings, walls, and floors must be well illuminated, so that the diffused light may be radiated into the empty spaces; and that the quantity may be the same everywhere, it will be necessary to multiply the sources of light, and to cover all the openings by which it may escape.

The exterior light enters by the windows during the day, and it is by them that the nocturnal illumination escapes. When Mr. Jablochkoff introduced electric lighting into the laboratory of the Sorbonne, the feeble effect it produced was astonishing. The building is covered with a glass roof, by which it is well lighted during the day, but which allowed the escape of at least one half of the light produced by the electric candles. This wasted light illuminated the high walls of the surrounding buildings, and gave a brilliant but useless illumination in the court. The experiment would have succeeded had the roof been covered with a thick white covering to throw down the light so prodigally wasted.

The same thing happens with gas, and will occur with electricity in the illumination of public places. All lamps waste half their light in radiation towards the sky. A simple reflector would return it to the ground and double the illumination.

These conclusions have been tested, and visitors to Paris to the Universal Exhibition saw there a street lighted by electricity, which, as described, was as clear and diffusive as moonlight.—*Chambers's Journal.*

New Application of Gas for Lighthouses.—Mr. J. R. Wigham read a paper before the Dublin Meeting of the British Association, on "New Application of Gas for Lighthouses." The paper consisted of three separate parts, the first being on the Quadriform Group Flashing Light.

Galley Head was a promontory on the coast of Cork, in the neighbourhood of which there have been several shipwrecks. The Commissioners of Irish Lights therefore determined to place upon it the most distinctive and powerful light which they could obtain. With this view, they adopted the Quadriform Group Flashing Gas Light. Those Commissioners were the first lighthouse authorities to make use of gas as an illuminant for important lighthouses. They had done him the honour to adopt the arrangements and burners which he had from time to time devised. His aim had been to combine the greatest possible intensity with the greatest possible volume in the gas flames which he employed. The power of the burner was obtained by a peculiar arrangement of fishtail jets, and by suspending over the flame an "oxidiser," by means of which the current of air was brought in contact with the most smoky part of the flame, rendering it not only smokeless but exceedingly white. The oxygen of the air was twice made use of; first, through the bottom of the flame; and secondly, at the top, where its action raised to a white heat a large quantity of solid carbon found there. The burner was superior to any form of Argand burner in this important particular, that it required no chimney-glass, and the cleaning and breaking of chimney glasses had caused considerable inconvenience in lighthouse maintenance.

The second portion of the paper was on the combined gas and electric light for lighthouses.

It had occurred to him that if he could add some intenser light to his large gas burner, so that it would not be used except in bad weather, a great improvement might be effected. He made many experiments, and at length arranged for what he termed a core for his burners. At first he used as the simplest and least expensive a rich hydro-carbon flame, intensified by oxygen; but he preferred the electric light, because of its greater intensity and the facility with which it could be applied. It was only intended to be used during fogs, so that no extra expense was incurred at any other time, but no expense should be spared when there was a possibility of saving human life.

The third branch of the paper dealt with a mode of lighting sea beacons from a position on shore.

When it was desired to maintain lights on beacons to which access by boat was difficult or expensive, gas, properly dried by chloride of calcium, might be applied as the means of illumination. The gas station on shore might command any number of beacons, which might be simultaneously lighted. During the day-time gas was supplied at a pressure equal to a column of water six inches high, to maintain a small jet in the lanterns on each beacon. The high pressure prevented the jet from being blown out by the wind, and the arrangement which he had devised enabled the operator to turn on the flame or diminish it to a small jet, as easily as the same result could be accomplished in the case of an ordinary light burning in an ordinary dwelling house.—*Iron.*

XVII.—ENGINEERING.

The Longest Span Bridge in the World.—The longest span or truss bridge in the world has been successfully completed by the Keystone Bridge Company in America —the bridge having been built for the Cincinnati Southern Railway over the Ohio river. This span (No. 3) is one of eleven, and is 519 feet long; it is over the main current. The bridge is built entirely of iron, except the cross ties for the track and the guard rails. All the spans rest on solid masonry piers, except the north-end approach, which has iron piers with masonry bases. All the river piers are on a rock foundation. The two supporting the long span are 110 feet and 119 feet high, and 11 by 26 feet under the coping.

Balance Pumps.—With a view to reduce the cost of raising water either from mines or pits, or in any other cases where large bodies of water have to be raised, Mr. Edwin Bourne, of Shifnal, Salop, has patented an improved pump. The lower valve and the bucket and clack are of the ordinary kind, having a stuffing box or cover immediately above them; the water is then diverted from the straight column by a branch pipe in a right line with the lower pipe, having at its top or upper end a second valve. This branch pipe then takes into a pipe, which continues the main column which has been broken, as before mentioned, and it is open at its lower end, and the water is supported on a plunger working within it. Thus the water is lifted to the desired elevation, and is by preference forced into a suitable tank. The pumps are worked in pairs, and fitted with the following arrangement of parts:—The pumps are fixed side by side at a convenient distance, and immediately above them is provided a suitable fulcrum, on which is fitted a lever of the desired length, and to this lever is attached the pump rods. At both the extreme ends of this lever is provided a suitable box or tank, which is fitted with valves at the bottom. When it is desired to commence pumping, water is raised into the first-mentioned tank.—*Mining Journal.*

Tube Wells for Large Supplies.—A paper on "Tube Wells for large supplies and in various strata" was read before the Society of Engineers, in the close of 1877, by Mr. Robert Sutcliff. Mr. Sutcliff observed that in laying down plant for obtaining large supplies of water, a number of tube wells were coupled together by horizontal mains, so that one pumping engine drew from many tubes. In this way, for the last eight or nine years, the leading breweries in Burton-on-Trent have obtained the bulk of their water supplies. Messrs. Allsopp and Sons pump 600,000 gallons daily from 30 three-inch wells, and Messrs. Bass and Co. 500,000 gallons from 25 tubes. Thus in one

town two breweries are obtaining sufficient water for a town of 40,000 inhabitants. Although some of these Burton wells are within a stone's throw from the Trent, the quality, level, and temperature of the water differ from those of the river water. The town of Carmarthen, in Wales, is supplied by 10 two-inch tube wells. In sandy soil strainers or filters are used, which prevent sand coming into the tubes. A tube well was sunk in a very fine sand at Chislehurst by pumping up six barrow loads of sand and replacing it with gravel. One advantage of the gravel filter is its imperishability, and if made sufficiently large the velocity of the water is not sufficient to bring the grains of sand within the area acted upon by the pump. The author observed that in rocks and other hard strata the method of sinking tube wells was similar to that employed in making artesian borings, but the mode of pumping and development of supply were entirely peculiar to the tube-well system. Bored tube-wells can be made through any stratum and to any depth that an ordinary artesian boring can reach. Mr. Sutcliff thought it possible that coupled tube-wells in the chalk might solve the problem of providing London with pure water.

Building a Lighthouse.—The lighthouse near the Isle of Sein, on the Breton coast, now being built, presented great difficulties of construction at the beginning, according to *Engineering*. The lighthouse was to be built on a hard gneiss rock, from 40 to 50 feet long and 25 feet wide, and the preliminary works could only be executed by the neighbouring fishermen, familiar with the waters. Accordingly, when the weather was favourable, two men wearing cork belts got out of their boats and lay on the rock, clutching the ground with one hand while they made holes, at intervals of three feet, with the other. While doing this they were covered with spray, and were often swept off by the waves. In 1867 only eight hours' work could be accomplished on the rock, and only 15 holes were made, but 40 holes were finished in the following year, and in 1869 the building itself was commenced.

A Deep Artesian Well.—There is now being bored at Pesth an Artesian well which will be deeper than any made hitherto. A grant of 1,000,000 fr. has been made to the engineers by the town on condition of furnishing an unlimited supply of hot water for the municipal establishments and public baths. The depth of the well is at present about 951 metres, and the temperature of the water is about 161° F. The work will be continued till the temperature is 178° F. The well furnishes daily 790,000 litres of hot water, rising to a height of 10·50m. This quantity of water will not only suffice for all the wants of the town, but will transform the environs into a sort of tropical garden. The upper layers have furnished some interesting data to geology. Among the mechanical inventions to which this undertaking has given rise may be specially noted an apparatus in which the water escaping from the well is utilised as a motor force imparting to the borer a velocity twice that which it had before.

XVIII.—MINES AND MINING.

A Mile of Coal.—The out-put of coal in the British Islands in 1877 amounted to 132,000,000 tons. A popular notion is that a great part of the crust of the earth is becoming used up by mining operations, and that if the soil that has been dug out of our mines were piled up it would make quite a mountain range. Let us reduce this to figures. A cubic mile is equal to 147,198 millions of cubic feet, and allowing 29½ cubic feet of coal *in the solid* to weigh a ton, we get just 5,000,000,000 tons of coal in one cubic mile, and this is a greater weight than all that has yet been raised in the British Islands. According to the most reliable statistics, the end of 1878 will about just complete the first cubic mile of coal, exclusive of waste in mining. If our fuel had been stored in mountain heaps on the surface, instead of being buried in the bowels of the earth, a very small mountain range indeed would have been equivalent to all the coal fields available to man in the whole of our earth.—*Nautical Magazine.*

A New Mineral.—Just before leaving Europe in the autumn of 1878, to attempt the North-East Passage, Professor Nordenskjöld sent to the Paris Academy of Sciences an account of a new mineral recently found in Sweden, and which he has named Thaumasite ("the wonderful"). Professor Nordenskjöld's paper states that the mineral has been carefully studied by his assistant, M. G. Lindström. Thaumasite has been met with in (1) specimens brought by Professor Nordenskjöld from the Gustav and Carlsberg mines, or the Bjelke mine at Areskustan, in 1859; (2) specimens of an old Swedish collection from the same mines 100 years ago, by M. Polheimer, mining engineer; (3) other specimens brought from the same mines this year, at Professor Nordenskjöld's request, after the analysis of Nos. 1 and 2 had shown the strange composition of the substance, which contains at once silicic acid, carbonic acid, and sulphuric acid. The microscopical analysis shows that the mineral is a genuine new species, and not a mixture. It appears to Professor Nordenskjöld that the curious composition of the mineral is very important for a knowledge of the transformation which the materials of rocks undergo, and he is convinced that thaumasite will be found in other mines when once the attention of mineralogists has been drawn to this interesting substance.

An Instrument for Determining the Prospect of Fire-Damp in Mills.—Prof. G. Forbes read a paper before the British Association, at their Dublin Meeting, describing an instrument for detecting fire-damp. The instrument consists of a resonator of

variable dimensions, and a tuning fork of definite pitch. The resonator is a metal tube 1 in. in diameter, and 15 in. long, in which a piston slides so as to regulate the length of the tube. This tube is fixed in a block of wood, to which is attached a tuning fork, whose points are just above the open end of the tube. The tuning fork is sounded in any convenient way, and the piston is moved out and in till the proper length is found, which is indicated by the resonator intensifying the sound of the tuning fork. With practice the length can be determined with tolerable accuracy. But the length depends upon the density of the gas, a light gas requiring a longer resonator, and by reading off on a scale the position of the piston a person can judge of its density. In this manner 1 or 2 per cent. of fire-damp, mixed with common air, can be detected. Borametric pressure produces no difference on the instrument. The temperature correction is made by reading off a thermometer of the proper dimensions, instead of reading off a fixed mark on the piston. The only error possible is by the presence of dense carbonic acid gas. But carbonic acid gas tends to destroy the explosive character of fire-damp, and it appears that if the presence of carbonic acid prevented the instrument from indicating fire-damp, it would certainly be sufficient to prevent the explosive character of the fire-damp.

The New Metal "Gallium."—A lecture on the new metal, gallium, was delivered by Professor Odlin at the Royal Institution in the close of February, 1878. The Professor said that the number of kinds of matter known to chemists which they have not succeeded in decomposing, but can trace undecomposed through distinct series of combinations, is 64. These have been roughly classified into metals, semi-metals, and non-metals, the first class being considerably the most numerous, and the several classes merging gradually into one another. The latest known of the non-metallic elements is bromine, which was discovered in 1826 by the eminent French chemist, recently deceased, M. Balard. Within the last 20 years, however, five new metallic elements have been discovered, being at the average rate of one new element every four years; while some evidence of the identification also of yet a sixth new metallic element has recently been put on record. But the latest known of the fully-made-out new elements is gallium, which was first recognized by M. Lecoq de Boisbaudran, in the autumn of the year 1875, and so named by him in honour of the land of its discovery, France. Like its four predecessors made known within the last 20 years, gallium was discovered by the process of spectrum analysis, applied in this instance in a special manner contrived by the ingenuity of M. de Boisbaudran himself, long eminent as a spectroscopist. The spectrum of gallium is characterized by two marked violet lines, the less refrangible of them being especially brilliant. Hitherto the new metal has been recognized only in certain varieties of zinc-blende, that of Pierrefitte in the Pyrenees having furnished the

chief portion of gallium hitherto obtained from any source whatever—nearly half a ton of this ore having been employed by M. de Baisbaudran to furnish the dozen grains or so of metal wherewith he has been able to establish the leading properties of the element. In its appearance gallium manifests a general resemblance to lead, but is not so blue-tinted or quite so soft, though it is readily malleable, flexible, and capable of being cut with a knife. Like lead again, and unlike zinc, gallium is not an easily volatile metal. Unlike lead, however, it acquires only a very slight tarnish on exposure to moist air, and undergoes scarcely any calcination at a red heat. The specific gravity of gallium is a little under 6, that of aluminum being 2·6, that of zinc 7·1, and that of lead 11·4. A most remarkable property of gallium is its low melting-point. It liquefies completely at 86 deg. F., or below the heat of the hand; and, still more curiously, when once melted at this temperature it may be cooled down even to the freezing-point of water without solidifying, and may be kept unchanged in the liquid state for months. Indeed, in the original communication of its discovery to the French Academy, it was described as a new liquid metal, similar to mercury; but on touching with a fragment of solid gallium a portion of the liquid metal in this state it at once solidifies. Unlike lead, again, gallium is a highly crystalline metal, its form being that of a square octahedron. In its chemical habitudes the rare element gallium shows the greatest analogy to the abundant element aluminum. In particular it forms a sort of alum not to be distinguished in its appearance from ordinary alum, but containing oxide of gallium instead of oxide of aluminum or alumina.

But the chief interest of gallium, from a scientific point of view, is connected with the history of its discovery. All previously known elements have been discovered, so to speak, accidentally, and their properties have been not in any way foreseen, but rather met with as subjects of surprise; but the blende of Pierrefitte was deliberately taken up for examination by M. Lecoq de Boisbaudran in the expectation of finding a new element—an expectation to which he was led, in the course of his study of the spectra of known elements, by a train of speculation of which he has not yet made known the details. The existence of an element having the characteristic properties of gallium was, moreover, upon entirely different grounds, predicted very definitely by a Russian chemist, M. Mendelejeff, in 1871, and in a more general way several years earlier by an English chemist, Mr. Newlands. This double prediction was based on a study of the relations of the known atomic numbers of the elements. These numbers have only lately been perceived to form a tolerably continuous seriation, which, again, is associated in a remarkable manner with the seriation in properties of the elements themselves. In the series of numbers, however, certain terms are here and there missing, and in particular a number was missing which should belong to an element having proper-

ties intermediate between those of aluminum and iridium. What these properties would be was predicted in most minute detail by M. Mendelejeff in 1871. He predicted, for example, that the specific gravity of the missing metal would prove to be about 5·9. Operating on very small quantities, M. de Bossbaudran, in the first instance, found the specific gravity of gallium to be 4·7; but on repeating his determination in 1876, with special precautions and on a somewhat larger though still very small scale, he found it to be exactly 5·935—certainly a most remarkable fulfilment of the prediction in regard to it.

A Mountain of Tin.—Tasmania, or Van Dieman's Land, the large island to the south of Australia, is becoming noted for the quality and extent of its tin supplies. Four years ago the value of its exports of tin and ore was $35,000, while last year they amounted to nearly $1,500,000. One of the most productive regions was the Mount Bischoff district, but this has been eclipsed by the discovery of a tin mountain at Mount Heemskirk, on the west coast. The "wash-dirt" is some 20 feet thick, and produces about 25 per cent. of tin; but the existence of solid seams of the metal, traversing the mountains in veins several feet in depth and width, has been demonstrated. Some "nuggets" weighing several hundred-weight each have been found, yielding nearly cent. per cent. of pure metal. Mixed with the tin, too, is a small quantity of gold' about 10 oz. to the ton, not sufficient in itself to render it worth seeking, but adding considerably to the tin miners' profits.—*Iron.*

The Mineral Statistics of Victoria.—We have received the "Mineral Statistics" of Victoria for the year 1877. From this volume we learn that the estimated yield of gold in that year was 154,107 ounces less than the quantity obtained in 1876. The falling off in the yields of gold from alluvial deposit is remarkable; in 1868, 1,087,502 ounces were obtained, but in 1877 only 289,744 ounces; but the results of quartz mining continue nearly the same, 597,416 ounces of gold being produced in 1868, and 519,899 ounces in 1877. Of coal they raised in this colony during the year 1877, 8,971 tons, valued at £13,505.

A Warning Bell.—Mr. Coret has invented what he calls a self-acting thermo-signal, which by ringing a bell makes known to all within hearing when an axle or any other part of an engine is over-heated. It is a small brass cylinder, containing a system of flexible metal disks, and a dilatable liquid, which is to be fixed to the part liable to over-heating. While all goes well the instrument makes no sign; but as the temperature rises the liquid dilates, forces out a small metal pin at the end of the cylinder, which, as the wheel revolves, strikes a bell, and thereby warns the attendants. Thus the necessity for constantly watching an indicator is avoided.

XIX.—MACHINES AND MACHINERY.

Wasted Water-Power.—In a lecture lately published, Dr. Siemens gives us some comfort with reference to the threatened exhaustion of our coal-fields. He tells us that a time may come "when our descendants will look back upon the indiscriminate users of coal with something like the same feeling that we look back upon the users of flint and bronze instruments." He argues that we should make use of water-power as our forefathers did. But, whereas they had no means of transporting such power to any distance, we can do so by means of dynamo-electric machines and copper wires. He calculates that the amount of force which is constantly being wasted at the Falls of Niagara, for instance, represents an aggregate of 16,800,000 horse-power. To make the matter more plain, he states that to find sufficient power to represent this lost force—*i.e.*, to pump the water back again—we should require an amount of coal equivalent to the total coal consumption of the world.

The Lubricator of the Future.—Everyone who has anything to do with machinery knows the difficulties which surround the question of lubrication. It is then with much satisfaction that we call attention to a new and admirable lubricator, patented by a *Mr. Hardinge, but of which Mr. George Chapman, of 109, Fenchurch Street, London, E.C.*, is both proprietor and manufacturer. This valuable contrivance is perfectly self-acting in principle and universal in application—in fact, it is all that could be desired, and bids fair to entirely supersede every other lubricating apparatus hitherto in use. The "Hardinge" lubricator claims attention upon the score of three recommendatory qualities — simplicity, efficiency, and economy. It is made in five different classes, and is adapted for use with machinery of every kind and size. From its automatical action the most minute economy in the use of the lubricant can be practised, the supply being regulated to the actual requirements of the machine in use, and ceasing simultaneously with the stoppage of the machinery or engine.

The five descriptions of the lubricator, as manufactured by Mr. George Chapman, are as follows:—No. 1 is made of gun-metal, and is adapted for supplying oil, tallow, or suet upon the piston of steam-engines, &c. It ensures an equal distribution of the lubricant over the entire interior of the cylinder, the supply being regulated with great nicety by a set screw plug pressing into a minim chamber and fixed by the driver. The inventor fairly enough, we think, claims that by no other than the "Hardinge" lubricator can the diffusion of lubricants throughout and over the entire working surfaces in

steam and other engines be efficiently, automatically, and economically performed.—No. 2 is of brass, and supplies oil to loose pulleys and running wheels. It has a movable fluted centre pin, which is so weighted as to ensure its prompt descent into the feed-tube as the axis revolves, thus rendering waste impossible.—No. 3, especially adapted for bearings of all kinds, can be obtained in toughened glass, and has a neck and stopper, so that oil can be introduced without removing the lubricator. It is fitted with a metal tube and three fluted pins of different make, the depth of the grooves enabling various qualities of oil—light, medium, or heavy—to be used, and rendering the cheaper sorts of oil as suitable as the more expensive kinds.—No. 4 is also a lubricator for bearings and journals. It is precisely similar to No. 3, but more cheaply made, the metal conducting tube being passed into the glass cup through a common kind of brass cap, or a wooden plug. Another special description is the "pendulum" lubricator, adapted for connecting rods, cranks, eccentrics, &c. The discharge of oil in this form of the lubricator is regulated by the movement of the pendulum, which in its turn is put in motion by the oscillation of the crank or what not to which it is affixed, and as the machinery thus furnishes and controls the supply of its own lubricant the personal attention of an engineer is unnecessary, and the risk of misadventure through neglect and inattention *is entirely* obviated, as a *constant and regular* supply is *ensured. The* "pendulum" lubricator is particularly valuable for use with marine engines, and the quantity of oil required for a voyage can be ascertained with unusual accuracy before the vessel starts. "Fifty per cent," remarks a writer in the *British and Mercantile Gazette,* alluding to Mr. Hardinge's invention, "is a saving well worth consideration, and such is stated to be the result of the use of the 'Hardinge' lubricators; and remembering the entire absence of waste and the utilisation of coarser lubricants which can be effected by means of them, we can well understand that such is really the case." Mr. George Chapman has received many complimentary and gratifying opinions on his invention from the chief engineers to the Admiralty, from the Metropolitan Board of Works, as well as from the leading mechanical engineers of the day. With so many advantages as it undoubtedly possesses, there can be no doubt that the "Hardinge" lubricator only has to be known in order to receive an eager adoption by the machinery-using section of the public throughout the world. New patents, we understand, are now being secured by Mr. George Chapman for further improvements in lubricators.

Babbage's Analytical Engine.—A committee report on Babbage's Analytical Machine was rendered to the British Association at their Dublin Meeting in 1878. After describing the principle of the machine, it states that it has not been possible to form any exact conclusion as to the cost. Nevertheless, there are some data in existence which appear to fix a lower limit to the cost. Mr.

Babbage, in his published papers, talks of having 1,000 columns of wheels, each containing 50 distinct wheels. This apparently refers to his "store." Besides the many thousand moulded pewter wheels for these, and the axes on which they are mounted, there is the "mill," also consisting of a series of columns of wheels and of a vast machinery of cams, clutches, and cranks for their control and connection, so as to bring them within the directing power of the Jacquard systems of variable cards and operation cards. Without attempting any exact estimate, the committee say that it would surprise them very much if it were found possible to obtain tenders for less than £10,000, while it would cost a considerable sum to put the design into a fit state for obtaining tenders. On the other hand, the cost might reach three or four times the amount above suggested. It is understood that towards the close of his life Mr. Babbage had contemplated carrying out the manufacture of the engine on a smaller scale, confining himself to 25 figures instead of 50, and to 200 columns instead of a thousand or more. This would, of course, reduce the expense of the metal work proportionately, but not materially. The conclusion at which the committee arrived was that they could not advise the British Association to take any steps to procure the construction of Mr. Babbage's analytical engine.

Wind Power.—A paper "On the Use of Wind-Power for Raising Water, and the Disposal of Sewage and Drainage, with Special *Reference to* Ireland," was read at the Dublin Meeting of the British Association, by Mr. J. Price. The average force exerted by the wind all over Ireland equalled 360 million horse power. Wind engines are now made which are self-acting, so as to provide against the effects of storms. Small towns and villages had not the means of bringing water from a distance, and might be supplied by deep wells and pumps worked by wind-engines at a very low cost. The same force might also be used for the removal of sewage from small towns by the infiltration process. A 1 horse-power wind-engine would suffice to keep one hundred acres of land drained. The same power might with advantage be employed in the drainage of bogs and the manufacture of peat. He believed that if Ireland were fully drained and properly tilled, the climate of that country would rank equal to that of England for the production of cereals.

A Novel Method of Sharpening Files.—The sand-blast invented by Mr. Tilghman has been utilized for the re-sharpening of worn files in a manner which promises to prove of some importance in our workshops. A few years ago that gentleman discovered that by driving a minute column of sand against sundry hard substances, their surfaces were abraded in a remarkable manner. For instance, a sheet of glass, covered in parts by a protecting cover of paper or other material, could be embossed or engraved in any desired pattern; and the effects thus produced were realized in many ways, and with other materials than glass. Recent experiments have demonstrated the

power of the sand-blast to re-sharpen worn files. The jet of sand is forced against the backs of the teeth of a file in such a way that it grinds them sharp; and practical experiments have demonstrated that files so treated may be re-sharpened several times, and are capable of doing about six times the usual amount of work before being re-cut. Those who know the cost of files in a large engineering shop will readily appreciate the economy effected by this method of renewing worn tools.

The American Mechanical Display at the Paris Exhibition of 1878.—Though the American collection at Paris is not large compared with those of other manufacturing nations, there are present so many of the contrivances which illustrate the subtle mechanical genius so well recognised already, that "Yankee" is almost a synonym of inventor, that it becomes to amateurs in mechanism a most fascinating stroll—that among the little railed-off spaces of the American section; for few of these contributions occupy more than a few square feet. Many of them are already widely known — the writing machine, by which the operator, touching a series of keys like those of an accordion, prints his thoughts or text more rapidly than they can be written legibly with a pen; the sewing machines, whose name is legion, and which here are illustrated by new variations for special work, a little attachment to one making it an embroidering machine of curious efficiency, and another a plaiting machine. The telephone and phonograph are there, and beside them an electric pen by the inventor of the phonograph—a pen which, carrying a tiny electromotor at the top, drives a needle through the paper 10,800 times a minute, forming a stencil sheet through which, with an ink roller, copies may be produced more rapidly than with a lithographic press, and of an excellence which must be seen to be appreciated.

Finest type of the Yankee contrivance is the Stow "flexible" shaft for transferring power round corners and to out-of-the way places. One sees the operator holding what seems at first sight to be a small garden hose, but furnished with an auger at its extremity, with which he thrusts and bores in every direction—over his head, under his feet, to the right, to the left—it upsets all one's ideas of rigidity. Pharaoh could not have been more surprised at seeing Moses's rod turn to a serpent than we were to see this rope-like affair eating into the planks set on all sides for it to work on. It is as good as a piece of legerdemain. It is really a "flexible shaft"—a cable of steel wires wound coat over coat, each successive coating in the reverse direction from the preceding, until the strength required is attained, and in which longitudinal flexibility is combined with circumferential rigidity.

Close by it stands Clough and Williamson's "wire cork-screw machine," which catches a straight piece of steel wire and throws it out a corkscrew of such temper that it may be driven through an inch deal plank and not yield a hair's breadth. The deftest waiter will take as long to pull a cork

as this machine to make half a-dozen cork-screws of an exceptionally good quality. Here is a screw-cutting machine, which takes a rod of iron, steel, or brass, and by an automatic series of operations drops screws at the other end of the machine. One tool cuts the point of the rod down to the dimensions of the screw, another cuts it off, having the head the full size of the rod, another takes it from the last and passes it on to have the thread cut, a cutter passes by and leaves it slotted, another with four iron fingers takes it and transfers it to a fifth cutter, where the head is finished, when still another tool comes to push it into the pan placed to receive it. No intervention is needed until another rod is wanted.

A set of shoe-making apparatus in another enclosure takes the leather in the hide and turns out, with slight manual application, a pair of shoes, sewed, pegged, or screwed, in about 15 minutes.

A novel planing machine shows a revolving cutter fixed in a disk which is, by means of an elbow arrangement of bands and pulleys, moved in any direction over the board to be planed, giving a very remarkable finish to the surface.

Those who have learnt to use the American gold pens will appreciate the excellence of the only good substitute for the gray goose quill, but the nice processes by which its perfection is attained will be less easily understood. A sheet of highly-tempered steel, stamped out in the required form, almost as the pens are to be used, gives no idea of *the processes by* which the golden plate is turned into highly and durably elastic pens, with points which, like the elasticity, endure for indefinite years. The process by which the gold pen is produced is not one of scientific elaboration or brilliant invention, but of laborious experiment and thoroughness and conscientiousness of manufacture which we are not generally disposed to credit American manufacturers with. First, an alloy is formed which can be hammered to a degree of hardness which makes it almost incapable of further impression from the hammer. The pen, reduced to its general form by the die, then receives a point by alloying with iridium of almost adamantine hardness, which is then cut into two and the slit produced, when the pen is hammered to the highest point of elasticity, the peculiar alloy used being, it is said, one which will condense under the hammer without spreading, until it has received the *maximum* of density alluded to, and the pen is then burnished into shape under a burnisher giving a pressure of about a hundred pounds weight, the effect of which is to secure the shape finally given against any usage, by equalizing the density of the metal throughout. Exhibits of gold pens are an indispensable, and characteristic part of any collection of the important American industries.

Perhaps, however, the most important display in this department, all things considered, is that of the Waltham Watch Company, their first in the European exhibitions. The readers of reports of the Philadelphia Exhibition will probably not

need to be informed of the admirable machinery by which the works of the Waltham watches are produced, or their singular exactitude, which enables any part of a watch to be replaced by the corresponding piece of any other watch of the same grade. In this mechanical production of machines America has long led the world, and the mechanism by which the English army rifle is still produced is with immaterial modifications a contribution from the American armouries. But in the Waltham works science has been brought to the aid of native ingenuity to such a degree that even since the Philadelphia Exhibition the fabrication of watches has gone through a large arc of another revolution. What was begun by applying such machines that their work was beyond competition on anything like equal terms from any hand work, is continued by the construction of the most essential parts of the watch on a new principle, which permits an approach to perfection unattainable by the old mechanism, however produced. Everyone knows that the great difficulty in making chronometers has been the compensation for the effects of expansion and contraction due to change of temperature, but what is less well known is that this difficulty is due less to the balance, which by its construction with a bi-segmental rim (of brass and steel) may be perfectly corrected, than to the expansion of the balance or hair-spring, which, being immensely longer, causes five times the error caused by the expansion or contraction balance wheel alone. The two pieces must be considered as one, and the compensation effected in the wheel or rim must answer for the spring as well as for itself. The theoretical and insuperable difficulty in this compensation has always been that the error caused by the expansion and contraction of the spring was in a different ratio from that of the correcting expansion or contraction wheel, and the two quantities may be compared to curves with two radii, which could be brought together at two points, but not to coincide throughout, so that if the compensation at the extremes of temperature is correct, the means must be in error, and *vice versâ*. The old compensation was, speaking broadly, in brazing a band of brass on one of steel, a process both theoretically and mechanically erroneous, since the contraction and expansion can only go on with a certain tendency to disrupture of the elements, and consequent inequality of the action. The new balance proceeds on an entirely different arrangement of the compensating metals. The rim, of plain steel, is cut nearly through, at the fixed extremities of the semi-circles, by several saw-tooth shaped notches, the number determined by experiment, and the brass is forced into these notches. The compensating weights are then put on at the other extremities of the semi-circles, instead of being distributed along them empirically, and it is found possible in this arrangement so to distribute the compensation and compensating weights as to give at will a compensation for the mean temperature, either in excess of, or

less than, the extremes, and, of course, to give a compensation which shall coincide throughout, which makes it theoretically possible to give absolute compensation for all temperatures at once. It is difficult to make this clear without diagrams showing the exact curves attained by experiment; but the nature of the result will be appreciated by those who know the mechanism of the balance. It is simply the theoretical elimination of all error from the compensated balance, so far as temperature is concerned. Practically and mechanically there will always be some, due to the inherent imperfection of human workmanship; but it is believed that the mean error, and equally the manual adjustment required, will be reduced to one-third of that actually obtaining under the old form of balance. But, to illustrate how involved are the various improvements in mechanism, it may be noted that the delicacy of construction of the new balance would only have been possible with the mechanism introduced by the Waltham Company, the precision of which may be judged from that of the micrometer last produced and shown at Paris, which measures the twenty-five thousandth part of an inch, and even indicates that so largely that it might be divided under a lens readily into hundred-thousandths. A micrometer screw-guage detects inequalities in the thread of a screw up to a hundred-thousandths, and a screw made for the Government Scientific Commission to correct the measures has been constructed, in which the *maximum* of error in the thread is less than one ten-thousandth of an inch.

In the department of firearms, in which the Americans have always maintained a certain advantage as to construction, there are exhibited by the Remington Arms Company two new forms of military rifle, one of which, the Lee gun, is obviously an improvement on all simple breechloaders hitherto used. The breech-block is the same as the Martini-Henry, but the opening is effected by the hammer, which holds the same place as in the old rifle, and can be worked by the thumb of the right hand. The breech-lock, when opened, is held open by a catch which is liberated by the flange of the metallic cartridge as it enters the barrel and the block, then rises to its place and closes the breech automatically. The motions are fewer and the action simpler than in the Martini-Henry, and the hammer indicates to the most careless glance the half and full cock. The second contribution of the Remington Company is a breechloader on the piston system, with an auxiliary magazine so arranged that a reserve of seven cartridges may be kept in the magazine and the gun used as an ordinary breechloader until a critical moment, when, by pushing aside the key of the magazine, the reserve is brought into play, and the seven shots may be fired with aim in ten seconds. A gun of this nature has long been a *desideratum* in the American service, and the advantage of this reserve magazine over the magazine system pure and simple, such as the Winchester and Swiss Vetterli guns,

is clear. While deliberate long-range fire is going on, the gun is used as an ordinary breechloader, and fed by hand; but when a charge is to be repelled, or firing at close quarters from any reason, the magazine is thrown open by command by a touch of the thumb, and the seven shots are delivered with an effect which can easily be imagined.

Owen Jones's improved revolver carries the construction of this useful weapon to a completeness which seems the *ne plus ultra.* The ingenuity expended on it is exhaustive. The pistol rejects exploded cartridges while it retains those which are not fired, refuses to revolve when empty, and releases the cylinder when required with a hitherto unattained facility. It is apparently able to do anything but load and fire itself.

A characteristic Yankee notion is a book-holder for keeping books in their place on a shelf. Two plates of sheet iron soldered together in an inverted T form answer this purpose perfectly, and are brought together to suit the books. The weight of the books on the flat limb of the ⊥ keeps the keeper in place, and the books may be crowded between two of them very compactly.

A locomotive of novel construction will receive the attention of railway men, and for districts where the quality of fuel is bad it will be a great boon, for it literally burns everything that is combustible-anthracite, coal-dust, wood, refuse of all coals. The improvement is effected by widening the fire-box and modifying the grate so as to secure an even and thin bed of combustible.—*Times.*

XX.—MANUFACTURES.

Printing in Colours.—In ordinary colour-printing, it is known, as many plates or stones have to be used as there are varieties of colour. M. Greth, of Zurich, has (according to the *Württ Gen. Bl.*) recently invented a process in which all the colours are printed at once with one stone. The colours used are fusible in heat. The most prominent colour is first poured on a perfectly even marble plate, and the parts not to be covered with this colour are cut out with a vertically held knife down to the surface of the stone. A second colour is now poured in, and the parts not to be covered with it are cut out, and so on, till the colours required are complete. The thickness of the colouring mass is determined by the number of impressions (1 ctm. for 1,000), and after each impression the plate is raised about $\frac{1}{100}$ mm. The paper is moistened with turpentine, and the impressions may be made with nearly the same rapidity as impressions with one colour only. The number of colours has a quite insignificant influence on the price of the prints, whereas the number of stones, in the ordinary method, raises the price enormously. M. Greth has produced pictures with 400 colours on one plate. The invention has been utilised in Paris for calico-printing; and in Alsace for imitation of Persian shawls.

The Solubility of Bottle Glass.—Macagno has determined the degree of solubility in water of a number of specimens of bottle-glass derived from many different sources, and ascertained in each instance "the corrosion degree" of a boiling solution of potassium bitartrate. He finds that the chemical composition of bottle-glass is hardly a correct indication of its quality. The amount of alkali or lime does not express the resisting power of the glass to water or acids. While the French glass is of very superior quality, the Rhenish, Madeira, Malaga, and Xeres bottles appear to have a very inferior composition. In order of colour we must set deep green in the first rank, in the second the white and common green, then the clear green, next the red-brown, while the worst are the yellow-brown, which must be regarded as likely to contaminate ordinary wines containing much potassium bitartrate. In the case of the deep-green glass of a Burgundy bottle the corrosion degree was 1·275; white glass used for Rhenish, Bordeaux, and Chianti, 2·020; common green glass used for Rhenish, Bordeaux, Champagne, &c., 3·202; yellow-brown glass used for Bordeaux, Madeira, Malaga, &c., 3·387; and the red-brown used for Rhenish, Ruster, Rohitscher, &c., 4·888.—*Chemical News*, 1878, xxxviii., 5.

Gas Cloth.—*Gastuch*, or gas-cloth, is the name given by Dr. Hirzel, of Leipzic, to a gas and water-tight stuff, which he has recently patented. It is produced by placing a large smooth piece of so-called guttapercha paper between two pieces of some not too coarse and dense material—*e. g.*, shirting (undressed)—and then passing the arrangement between heated rollers. The outer pieces of shirting combine in the most intimate way with the enclosed guttapercha to form a material which is impenetrable by gas and water. It may be made still denser and more resistant by being coated on both sides with, *e.g.*, copal lac. The substance is conveniently flexible, and will remain proof against variable influences of weather and external temperature. It can be applied to all those purposes for which waterproof material is used, and it is well adapted to form gas-tight membranes for regulators of pressure of compressed gas, bags or sacks for dry gas-meters, as also dry gas-reservoirs.—*English Mechanic.*

Imitation Rosewood.—A new method for treating the surface of certain woods so as to produce imitations of rosewood, walnut, &c., is thus described. A concentrated solution of hypermangate of potassa is spread on the surface of the wood, and allowed to act until the desired shade is obtained. Five minutes suffice ordinarily to give a deep colour. A few trials will indicate the proper proportions. The hypermangate of potassa is decomposed by the vegetable fibres with the precipitation of brown peroxide of manganese, which the influence of the potassa, at the same time set free, fixes in a durable manner on the fibres. When the action is terminated, the wood is carefully washed with water, dried, and then oiled and polished, in the usual manner. The effect produced by this process on several woods is remarkable. On the cherry, especially, it gives a beautiful red colour. The colour resists well the action of air and light, and the process seems very simple.—*Furniture Gazette.*

A Novelty in Yarn.—Mr. Louis Cordonnier has hit upon a singular method of producing a novelty in yarn; this is not surprising when we consider the immense number of varieties of cloth which our neighbours designate as *nouveautés*, and what we term "fancy cloths." After having tried every imaginable way of weaving to produce different effects, there hardly remains anything new but to return to the spinning. Mr. Cordonnier takes a mule, and places upon this another row of rollers, through which, at a different speed, he passes a coloured or plain thread, but twisted in the reverse way of the direction of the yarn to be operated upon. Thus, when the spindles revolve, the two threads are twisted, but the additional yarn is at the same time untwisted; he then takes this doubled yarn and twists it again with the same or any other yarn, but running it again in the opposite direction, which untwists the first thread, and produces a very singular effect, and one which in the loom, will, no doubt, prcduce a novelty.—*Textile Manufacturer.*

Bird-Lime in Japan.—Among

the many industries of Japan is the manufacture of bird-lime; and an interesting account is given in Consul Annesley's commercial report on Osaka and Hiogo of the various uses to which this article is put by the Japanese. It is, of course, principally employed for the snaring of birds and animals. By its means animals as large as monkeys are caught. When once they get the stuff on their paws they soon cover themselves with it, and so exhaust themselves in trying to get rid of it that they fall an easy prey. Birds, also, as large as ducks, are taken by an ingenious process. The young shoots of the fugi (Wisteria), which are strong, light, and flexible, are knotted together, smeared with bird-lime, and floated out to sea. Numerous wild fowl are bagged by this means, and the tackle will serve any number of times till the bird-lime dries. Small birds are caught in various ways—some by means of a decoy bird concealed near a patch of tempting food, which is plentifully planted with little splinters of bamboo like large needles, the upper half of which is covered with lime. Others are caught while on trees by means of a long and slender bamboo, the top of which is anointed with the lime, and then stealthily thrust against their feathers. Rats are easily caught by spreading a small quantity on a piece of board or paper, and placing it near their holes. It is spread upon a bamboo leaf, and used during the summer for catching flies or other insects. Flea-traps are made for its service, and occasionally used by the Japanese in bed. This trap looks like a toast-rack, and consists of a piece of board smeared on the upper surface with the lime, surmounted by semicircles of bamboo to keep the bedding off the board. Bird-lime is also used by the Japanese for medicinal purposes, and is considered one of the best cures for wounds, cuts, &c. Japan is the only country where it is regularly manufactured on a large scale, the principal tree from which it is made being a dark evergreen growing on the mountains in the south.

The Progress of Tempered Glass.—At a Meeting of the Société d'Encouragement, during the winter of 1877–78, M. de Luynes made a communication in M. de la Bastie's name, on recent progress achieved in the industry of tempered glass. Numerous specimens were placed on the table, presenting forms the most varied and correct. There were tubes for lamp glasses and gas burners, laboratory mortars with their pestles, capsules of all sizes and forms for pharmacy and chemistry, plates of glass, crystal, and enamel, tea and coffee-cups of white enamel, &c. A striking experiment was made:—Some ordinary glasses were placed in a salad-basket with drinking glasses of the same form, but of tempered crystal; after a few shocks, the ordinary glasses were all broken, while all the tempered glasses remained intact. It was stated that the processes of manufacture have been simplified and combined with the ordinary operations of glass-making, so as to diminish considerably the expense, and give more regular forms and more per-

fect execution. The objects made with the liquid material are brought directly, while still red, into the tempering bath, and are not now reheated (as formerly) to the point of softening (which often caused alteration of form). Bottles, drinking-glasses, lamp-tubes and glasses, and concave objects, containing air which would oppose the entrance of liquid in tempering, are received on a bent tube, a sort of syphon, which, at the moment of immersion allows the escape of the air.

Decorative Glass.—The present methods employed to render glass opaque are likely to fall into disuse when the new process, recently invented by M. Aubriot, becomes better known; for muslin glass, as it is termed, can be produced in a variety of colours and in a number of pleasing designs, which will compare favourably with the dull monotony of the present ground-glass, and even with etched or embossed glass. A sheet of the material to be covered is floated with a vitrifiable pigment dissolved in gum-water, and when dry the stencil pattern is laid on, and the exposed parts are cleaned with a stiff brush. The sheet of glass is then placed in a furnace, and the remaining colour is burnt in. When simple opaque glass is desired, a plate is covered with gum water and dried; it is then placed in a frame, and a piece of tulle, muslin, or other suitable substance is stretched over it, in close proximity to the gummed surface. The frame is then placed in a box containing a quantity of the powdered pigment, which is forced against the muslin by an air-blast, and, passing through the interstices, adheres to the gummed glass. In this way the patterns of the lace or muslin are reproduced, and the powder being first caused to adhere firmly by placing the plate in a steam chamber for a few moments, is burnt in, as before described, in a special furnace. By means of stencil-plates of different designs, and muslin and lace of different patterns, together with pigments of various hues, some very beautiful glass screens have been produced, which for many purposes will be preferred to the plain opaque glass at present manufactured.

The Prussian Prize Method of Preparing Plaster Casts.—Some time ago a prize was offered by the Prussian Government for a method of preparing plaster casts in such a manner that they might be washed without injury. The prize was awarded to Dr. Reissig, of Darmstadt, and the *Industrie Blätter* gives the following description of the process:—In preparing these casts it was not only desirable to obtain a surface which should not wash away, but also to include a simple process for preventing dust entering the pores and rendering them more easily cleansed. Laborious experiments convinced Dr. Reissig that the only practical method of accomplishing this and retaining sharpness of outline was to convert the sulphate of lime into,

1. Sulphate of baryta and caustic or carbonate of lime; or,

2. Into silicate of lime by means of silicate of potash.

Objects treated in this way are not affected by hot water or hot soap solutions, but, from the method of preparation, they re-

main porous, catch dust, &c., and when first put into water eagerly absorb all the impurities. To avoid this evil, he subsequently coats the articles, now rendered waterproof, with an alcoholic soap solution, which penetrates more easily, deeper, and more freely in the pores than an aqueous solution. After the alcohol evaporates a layer of soap remains which fills the pores, and when washed it is converted into suds which easily remove the dust without allowing it to penetrate.

Process with Baryta Water.—This is the simplest, easiest, and cheapest method. It depends upon the fact that gypsum, or sulphate of lime, is converted by baryta water into sulphate of baryta (which is totally insoluble), and caustic lime which is converted by contact with the air into carbonate of lime. The practical method of carrying this out is as follows:—A large zinc vessel is required with a tight-fitting cover. In each vessel is a grating made of strips of zinc, resting on feet 1¼ in. high. This vessel is two-thirds filled with soft water at 54° to 77° Fah., and to every 25 gallons of water is added 8 lb. of fused or 14lb. of crystallised, pure hydrated oxide of barium, also 0·6 lb. of lime previously slaked in water. The solution stands about 4° Beck. As soon as the baryta water gets clear it is ready to rceeive the casts. They are wrapped in suitable places with cords, and after removing the scum from the baryta bath are dipped in as rapidly as possible, face first, and then allowed to rest upon the grating.

Hollow casts are first saturated by rapid motions, then filled with the solutions and suspended in the bath with the open parts upwards. After the cords are all secured above the surface of the liquid, the zinc vessel is covered. The casts are left in it from 1 to 10 or more days, according to the thickness of the waterproof strata required. After taking off the cover and removing the scum, the plaster casts are drawn up by the strings, rinsed off with lime water, allowed to drain, carefully wiped with white cotton or linen rags, and left to dry, without being touched by the hands, in a warm place free from dust. The same solution which has been used once can be used again, by adding a little more baryta and lime.

Of course this process can only be applied to casts free from dust, smoke dirt, coloured particles of water, rosin and varnish, soap, animal glue from the moulds, or sweat from the hands. To prevent the casts getting dust upon them, they should be wrapped in paper when taken from the mould and dried by artificial heat below 212° Fah. If in spite of every precaution the casts when finished show single yellow spots, they can be removed in this manner:—The perfectly dry, barytated casts saturated with carbonic acid are painted over with water and oil of turpentine, then put in a glass case and exposed to the direct rays of the sun. All spots of an organic nature will then disappear; but, of course, rust, smoke and mineral spots cannot be removed in this way.

In the place of cold baryta water the casts may be placed for half an hour in a concentrated

solution of baryta heated to 104° to 122° Fah. This has the advantage that casts may be put in before drying. As the casts treated in this way are not hardened very deeply, and are still porous, it is well to place them subsequently in a cold bath for a longer time.

The casts are now ready, as soon as perfectly dry, for the soap solution. For cheapness Dr. Reissig selects a pure, good, hard soap, shaves it up, dries it, and dissolves it in 50 or 60 per cent. alcohol; 10 or 12 parts of alcohol to one of soap. Such a solution of Marseilles soap, known as "spiritus saponatus," can be had at any drug store. The finest appearance, as well as a high degree of durability, is obtained by the use of a solution of stearate of soda in strong alcohol. Both the solution and cast should be warm, so that it may penetrate as perfectly and deeply as possible. It is no harm to repeat the operation several times, so long as the liquid is absorbed by the cast. When dry the cast is finished.

Process with Silicate of Potash Solution.—This process depends upon the conversion of the sulphate of lime into silicate of lime—an extremely hard, durable, insoluble compound—and is accomplished by the use of a dilute solution of silicate of potash containing free potash. To prepare this solution Dr. Reissig first makes a 10 per cent. solution of caustic potash in water, heats to boiling in a suitable vessel, and then adds pure silicic acid (free from iron) as long as it continues to dissolve. On standing, the cold solution usually throws down some highly silicated potash and alumina. It is left in well-stoppered glass vessels to settle. Just before using it it is as well to throw in a few bits of pure potash, or to add one or two per cent. of the potash solution. If the plaster articles are very bulky, this solution can be diluted to one-half with pure water.

The casts are silicated by dipping them (cold) for a few minutes into the solution, or applying the solution by means of a well-cleaned sponge, or throwing it upon them as a fine spray. When the chemical reaction, which takes place almost instantly, is finished, the excess of the solution is best removed with some warm soap water or a warm solution of stearin soap, and this finally removed with still warmer pure water.

The casts which can be immersed or easily moved around may be treated as above when warm; a very short time is required, but some experience is necessary. In every case it is easy to tell when the change is effected, from the smooth dense appearance, and by its feeling when scratched with the finger-nail. It is not advisable to leave the casts too long in the potash solution, as it may injure them. A little practice renders it easy to hit the right point. The fresher and purer the gypsum and the more porous the cast, the more necessary it is to work fast. Castings made with old and poor plaster of Paris are useless for silicating. These silicated casts are treated with soap as before.

In washing plaster casts prepared by either method, Dr. Reissig recommends the use of a clean

sponge, carefully freed from all adherent sand and limestone, wet with lukewarm water and well soaped. They are afterwards washed with clean water. They cannot, of course, be washed until thoroughly dry and saturated with carbonic acid. The addition of some oil of turpentine to the soap is useful, as it bleaches the casts on standing. The use of hot soapsuds must be avoided.

Plaster of Paris.—M. Landrin has just communicated to the Academy of Sciences the results of long-continued studies relative to the different qualities of this substance, and the information he furnishes may be of considerable practical value to architects, builders, modellers, and others whose business requires the use of this material. He finds that the more or less rapid setting of the plaster is due to the mode in which it is burned. Its properties are very different when it is prepared in lumps or in powder. The former, when mixed with its own weight of water, sets in five minutes; while the latter, under similar conditions, takes 20. The reason probably is that plaster in powder is more easily burned than when it is in lumps, and what tends to prove that fact is that when the latter is exposed longer than usual to the action of fire it sets more slowly. Gypsum, when prepared at a high temperature, loses more and more its affinity for water, retaining, however, its property of absorbing its water of crystallisation. Plaster heated to the red, and mixed in the ordinary manner, will no longer set, but if, instead of applying the ordinary quantity of liquid, the smallest possible portion is used, say one-third of its weight, it will set in ten or twelve hours, and then it is less porous and becomes extremely hard. To prepare plaster for moulding it must be burned slowly for a long time, sufficiently to drive off all its water, and for its molecules to lose a part of their affinity for the liquid. M. Landrin stated that a similar result could be obtained by other means. If the plaster is exposed to the fire of the kiln for a time short enough to allow it to retain 7 or 8 per cent. of its water, it is useless, as it sets almost immediately. If, however, the burning is again resumed, the substance soon loses its moisture, and, if then exposed to the air, it very rapidly retakes its water of crystallisation, and then absorption continues more slowly. It can then be used; it sets slowly, but acquires great hardness.

XXI.—PHOTOGRAPHY.

Sun Engraving.—In the summer of 1878, Petermann's *Mittheilungen* contained a highly interesting paper entitled "The Sun in the Service of Geography," in which the advantages of the process of heliogravure, or sun engraving upon copper, as practised by the Austrian Military Geographical Institute, are dwelt upon. The maps of the new Austrian ordnance map are carefully drawn on paper, on a scale of 1: 60,000. They are then reduced photographically to a scale of 1: 75,000, transferred upon copper, touched up, and printed. In this manner each sheet of the map can be produced in nine months, while the same amount of work engraved in the usual manner requires nearly 46 months for its completion. The whole of the Austrian staff map, consisting of 715 sheets, will thus be completed in 10, 11, or 12 years. No less than 271 have been published since 1874. The advantages of this process, as regards cost and rapidity of publication, are evident, and they fully compensate for any slight inferiority in the appearance of the work. An engraver, to whom we showed one of the maps produced in this manner, firmly believed that it had been engraved upon copper. If the Ordnance Survey Office were to avail itself of this process, the one-inch map of the United Kingdom, for which we shall have to wait under present arrangements for years, might be completed very speedily. The Ordnance Survey of Palestine, at all events, might be produced in this manner at comparatively little expense, and in a very superior manner, as an examination of a specimen map in the *Mittheilungen* will show. We ought to mention that a similar process, invented by Colonel Avet, has been in use for several years past, in the office of the Italian General Staff.—*Athenæum*.

Photographic Reproduction.—A new process adopted by M. Pellet, an engineer and chemist in Paris, for photographic reproduction in blue lines on white paper of industrial drawings, plans, maps, &c., has recently been brought before the French Société d'Encouragement. It is based on the property of perchloride of iron of being reduced to protochloride by light. The latter salt is not changed by a solution of prussiate of potash, while the former is immediately coloured blue. The copying paper is sensitised by immersion in a bath formed of 100 of water, and 10 of perchloride of iron, and five of oxalic acid (or other vegetable acid). The drawing, on transparent paper, is placed on a dry sheet of the copying paper, which is called "cyanofer," and exposed to the light under glass (15 to 30 seconds to the sun in [illegible]

and 40 to 70 seconds in winter; in shade the exposure varies from 2 to 40 minutes, according to weather). The electric light may be used. After exposure the sheet is placed in a bath of prussiate of potash (15 to 18 per cent. of water), which immediately colours blue all the parts where the perchloride has remained intact, but does not affect the parts where the salt has been reduced by the light. Then the drawing is washed with water, and passed into a bath of 8 to 10 per cent. of hydrochloric acid, which removes the salt of protoxide of iron; then it is washed again and dried. The drawing now appears in deep blue tints on a very white ground, and looks like a drawing made by hand with blue ink.

Platinum Pictures.—A paper on "A New Process of Photo-Chemical Printing in Metallic Platinum," was read at the Dublin Meeting of the British Association by Mr. W. Willis, jun. It is a fact well known to chemists that metallic platinum in all its states, massive and molecular, is totally unchanged or unaltered by atmospheric influences. It is also well known that platinum in a finely-divided state has an intensely black colour. Now if a picture be produced on paper or other suitable substance, in which the dark portions and shades are formed by this black finely-divided metal, it is evident, so far as this metallic pigment itself is concerned, that the picture is perfectly permanent and unalterable. The object of this process is to produce pictures in which this result is obtained. The chemical reaction upon which the platinotype process is based is one discovered by Mr. Willis some years ago. He found that a hot solution of ferrous oxalate in potassic oxalate instantly reduced platinum to the metallic state from its chlorides and other salts.

The remarkably simple form the process now takes may be briefly indicated as follows:—Paper is coated with a mixture of aqueous solutions of ferric oxalate and potassic chloro-platinite, then dried, and exposed to light under a negative. After it has had a sufficient exposure it is floated on a hot aqueous solution containing potassic oxalate and a salt of platinum. This solution instantly develops the picture, which is then washed in one or two solutions, to remove the chemical salts adhering to the paper. When dried the print is finished. This printing process derives considerable interest from the fact that it is the first in which platinum in the metallic state has been made use of as a pigment, and that it is the first photo-chemical process giving permanent results of any practical value, in which the particles of pigments forming the picture are imbedded in and entangled amongst the fibres of the paper on which they are printed, and do not depend for their adhesion on the use of any sizing material.

XXII.—LOCOMOTION.

Water-heated Tires.—On the railway from Moscow to Nijni the tires for the wheels have for a considerable time past been heated by immersion in hot water—instead of by fire—before shrinking on the wheels. Near a boiler stands an iron vessel of water, which is heated to 100° C. with the steam. The tires are immersed for 10 to 15 minutes; then raised by a crane, and brought on the body of the wheel. Three workmen are required, and in 11 hours they operate 12 to 14 tires. The difference of diameter is about $\frac{3}{4}$ mm. for every millimètre. It is said that this mode of heating has the advantage of giving greater regularity. According to observations made on the railway named, 37 per cent. of the tires shrank on by the old method came off, and 5 per cent. were broken in six years; whereas the loosening has been less than 1 per cent. in three years in the case of the water-heated tires, and only one tire has broken.

An Automatic Steam Alarum.—An automatic steam alarum, for use on secondary railways in Germany, is manufactured by M. Dülken, in Düsseldorf, and has the following arrangement:—A small steam cylinder is connected by a steam-pipe with the cylinder of the locomotive. It has a stop-cock inserted in the middle of the cylinder cover, and operated by means of a draw-rod. In the little cylinder there is a strong spiral spring on one side of the piston. The piston-rod is connected by a drawing-rod with the lever of the alarum, which has a double hammer. When the stop-cock is opened steam enters on the backward passage of the locomotive piston, behind the piston of the small cylinder, and drives it forwards. Thereby the lever is raised, and one hammer is made to strike on the bell. When, on the other hand, the locomotive piston moves forwards, no steam enters the small cylinder, but the compressed spiral spring now comes into play, drives the piston with the lever back, and causes a stroke of the second hammer on the bell. The steam under the piston can escape through a hole in the cylinder wall whenever the lower piston surface reaches this; thus the play of the piston is limited.

Communication between Passenger and Guard.—Mr. Henry Morris, of Manchester, has patented an invention for securing a trustworthy and convenient communication between railway passengers and guards. The continuous cord system now generally in use is alleged to be inefficient. It is also a source of inconvenience and expense to the railway companies, and has been condemned by the Board of Trade. In Mr. Morris's plan the attention of the guard is attracted

explosion of two waterproof detonators, or fog-signals, which are attached to the end of each carriage. In the centre of each compartment, near the lamp, and therefore easily accessible, a short chain, something like a bell-pull, is suspended a few inches from the roof, and by its means a passenger can with one pull explode the fog signals in rapid succession, and at the same time cause a red or white semaphore to appear at right angles to each side of the carriage. Against any mischievous use of the communication, a check is provided by which the compartment in which the signal has been given is at once indicated. The lamp in the compartment nearest the signal end of the carriage can be raised above the roof by a simple addition to the apparatus, so that it could be seen at night by a signalman, who would be able to stop the train at the next signal box; but this is considered to be scarcely necessary, inasmuch as if the guard did not hear the reports of the fog-signals, they could be repeated from carriage to carriage until his attention was attracted. The machinery for each carriage is complete in itself. A carriage-truck or horse-box can be added or taken off at will, and trains can be joined or divided at junctions or other places without the loss of time attendant upon the present system.

The Narrowest Gauge Railroad.—There is now in operation in Massachusetts a steam railroad of 10 in. gauge, projected by a young mechanic and engineer. To show how narrow and yet safe *a track* may be, with his own *hands he constructed* a railroad, having but 10 in. width of track, from the elevated village of Hyde Park down to the depôt. He also, with his own hands, constructed the cars to run on the track. In these he carried in six weeks over 3,000 passengers from the village down to the depôt, without the slightest injury to any one. There were several short curves on the way, and the track crossed the highway twice. The people of Billerica, wishing a road through their town from North Billerica, on the Boston and Lowell Railroad, to Bedford, a distance of 8½ miles, requested the projector, Mr. George E. Mansfield, to come and give the people a lecture on narrow-track railroads. Some said, "It is a chimerical notion;" but others gave a helping hand, and secured a movement so far as to get up a petition for a charter from the Legislature. The charter was allowed. Then the right of way was secured gratis the whole distance. Next the stock was subscribed. Then came the building of the road, which was completed by the 1st of September, 1878, so that cars passed with passengers over the entire route that day, and secured the right of way. There are 11 bridges on the route, one over 100 ft. long. The rail weighs 25 lb. to the yard. The road is well built and equipped; one grade is 155 ft. The cars and engines of the road at once attract and fix attention. The engine is behind the tender and next the cars, so that, when the train moves, the car next the engine draws down upon and increases the adhesion of the engine to the track. Both engine and cars are constructed so as to be very near

the ground, giving great advantages in regard to safety, also very little oscillation. The cars have one seat on each side. The length of the cars allows thirty seats.—*Railway World.*

Man as a Flying Animal.—The Annual Meeting of the Aëronautical Society of Great Britain, held at the Society of Arts in June, 1878, was a very interesting and instructive meeting, as it showed that considerable progress had been made in overcoming the mechanical difficulties to be surmounted. Mr. Thomas Craddock read a paper on "Flight by Man," but his conclusions were not assented to by the scientific part of the audience.

Mr. Thomas Moy followed, and remarked that the popular mind was peculiarly obtuse to simple facts which should easily be grasped, and that even scientific men failed to appreciate the importance of the demonstrations which had been worked out by that society. The amount of success with models, he contended, was so palpable, that men of capital did not exhibit much wisdom in their non-encouragement of efforts on a larger scale. If a tin box of one cubic foot capacity were filled with gas capable of raising one ounce to the cubic foot, and if the tin of which it was made weighed one ounce per square foot, then it would weigh six ounces if filled with air, and only five ounces if filled with gas.

Mr. Moy contended that although this *one* cubic foot of gas, enveloped in six square feet of material, would not float in the air, yet that it was as good a demonstration (or it *ought* to be), to a scientific man, as if it contained thousands of feet of gas, and carried people up. If, however, he made a box of the same materials, one ounce to the square foot, but *six* feet in measurement in every direction, this would require 216 *square* feet of materials, but it would contain 216 *cubic* feet of gas, and, therefore, it would just float, and the same obtuse minds which condemned the first experiment would applaud the second. This exactly illustrated the case in which Mr. Moy had, three years ago, demonstrated the possibility of flying by steam, by lifting 120 lbs. with his steam engine of three horse power. This feat was quite sufficient to prove that, with a steam engine of 100 horse power, 4,000 lbs. could be raised; and, as the 100 horse power engine would be relatively lighter than the three horse model, so the margin of carrying power would be ample, as far as aëronauts and passengers are concerned. Mr. Moy then exhibited and explained a working model aërial machine with circular aërophanes, and driven by two screws worked with india rubber springs.

Next Mr. F. W. Brearey, the Hon. Secretary of the Society, gave a lecture on the flights of birds, which was beautifully illustrated with working models, driven by india rubber springs, a number of which travelled across the hall of the Society of Arts and struck the wall with considerable force. A model of an albatross, of life size, elicited much applause.

XXIII.—THE MACHINERY OF WAR.

Illuminating Rockets.—Experiments have been made by the German artillery with a new rocket, which is intended to temporarily illuminate the siege or other works of an enemy. Fifteen of these rockets were issued during the course of 1878 to each regiment of fortress or garrison artillery in the German army, and the reports sent in announced that the results of the trials made with them were exceedingly satisfactory. The head of the new rocket contains fifty-seven large and seventy-two smaller magnesium stars, which burn for fourteen seconds. The range of the rocket is 2,000 mètres, but it can be fitted to explode at any desired distance from its point of departure. The stars, when burning give a white light of so great intensity that surrounding objects are as distinctly visible as by day. When it is desired to illuminate the enemy's works for a longer period, a number of rockets are fired at intervals of six or seven seconds, two troughs being arranged for the purpose, ten mètres apart. The weight of the rocket is about 26 lb.

A Marvellous Mitrailleuse.—On June 7, 1878, Mr. Ackers, agent to Dr. Gatling, inventor of the mitrailleuse, tried at Sealand Range, Chester, three new patent Gatling guns which have never before been tried in England. The *mitrailleuses* were first tried at 1,000 yards range. When everything had been arranged a signal was given, and the weapon poured out a literal hail of bullets, the majority of which struck the canvas target, and tore it all to shreds, and penetrated quite through the stout two-inch oak supporting the poles. Accurate time was kept, and it was ascertained that the mitrailleuse fired 1,000 rounds per minute, which is 300 or 400 rounds per minute faster than any other Gatling gun. Experiments with the weapon were then tried at 800 and 600 yards range, and the way in which the bullets were hurled at the target and the marvellous precision with which they struck astonished every one present. A sparrow must have been killed flying across the line of fire. The bullets which fell a little short tore up clods of earth as large as a fist, and hurled them right over the target into the marksman's retreat. The opinion of competent judges is that this is the most destructive weapon ever invented.

A New Repeating Carbine.—A new repeating carbine has been invented by Captain Valmisberg, of the Austrian army. The mechanism is said to work with wonderful precision, and can be adapted to any of the usual types of barrel. The cartridges are contained in a chamber holding nine, which are successively pushed into the barrel by a slight motion

of the finger. The whole charge —that is, the nine cartridges — can be fired in 18 seconds, and the chamber can be refilled in nine seconds.

Balloons for Military Purposes. —At one of the Meetings of the Scientific Congress assembled at Havre, in the latter part of 1877, an interesting paper was read detailing the work that had been done by the Commission appointed by the French Minister of War to examine how far balloons can be improved and utilized for military purposes. The investigations of the Commission were divided into three classes—namely, those relating to captive balloons, to free or postal balloons, and to balloons capable of being guided in any given direction. With regard to the first-named balloons, the Commission has recommended important improvements in the manufacture of the material of which the balloons are made, in the manner of suspending the car, in the method of anchoring the balloon to the earth, and in the apparatus for generating the hydrogen gas used for inflation. For free balloons the Commission has recommended the adoption of a valve and ballast-discharging arrangement which act automatically, and keep the balloon constantly at any height decided on beforehand; and an improved grappling-iron for finally stopping the balloon has also been suggested. With regard to the third class of balloons the Commission recommend, as a means of steering the balloon, a screw, applied, not as in most experiments which have hitherto been made, to the car, but to the centre of the balloon itself. The trials made with the steering apparatus suggested were, it is true, not altogether successful; but the results achieved showed that it was possible, even under unfavourable circumstances, to cause the balloon to diverge several degrees from the direction in which the wind was blowing.

The Telephone in Warfare.— An officer of the Prussian army published in the *Militär-Wochenblatt,* during the course of 1878, an interesting account of some experiments made by him, in order to determine to what extent the telephone can be utilized by the outposts of an army. A portable telegraphic apparatus has already been introduced into the German army for establishing communication between the several fractions of an outpost line; but as, when a telephone is employed, neither Morse's instruments, nor batteries, nor transmitting keys, nor galvanometers, nor, what is perhaps of more importance than all, skilled manipulators, are required, the newly-invented instrument will naturally be much more serviceable for outpost work than the ordinary telegraphic arrangements, provided that no practical difficulties stand in the way of its employment. The results of the experiments made by the Prussian officer appear to show that there is nothing to prevent the telephone being used for the purpose referred to. Posts were stationed representing pickets and their sentries, and although the weather was very cold—the thermometer standing at 3 deg. below the freezing point, and a strong wind blowing

—conversation was carried on with ease by men 300 and 400 yards apart. The only precaution taken was to make the men using the telephone pull the hoods of their great coats over their head and ears in order the better to confine the voice of the instrument. The wire used was arranged on a reel, fixed on a man's knapsack in such a manner that, as the man walked forward, the cable unwound itself behind him; and it was found that by this means the wire could be laid at the rate of 100 yards a minute.

Military Ballooning.—Military ballooning, which has during late years taken such an important place in the army corps of neighbouring countries, has at last met with some recognition at home, for experiments have lately been carried on at Woolwich with a view to testing the actual value of the system. Captive balloons are no doubt, under certain circumstances, useful for purposes of observation; but the difficulties in the way of gas-making in the field form a great obstacle to their employment. A plan has lately been devised for obtaining automatically bird's-eye views of an enemy's camp. This is done by means of a small balloon which is just large enough to raise the weight of the photographic camera which forms its car. The cap or cover of the lens is controlled by an electro-magnet, the connecting wires of which pass to the ground. When the balloon is raised to a certain height, the depression of a key uncovers the lens for the fraction of a second, and an instantaneous view of the position is secured. The process employed is that in which a sensitive tissue is used in lieu of glass plates.

The Bayonet.—An interesting account of that once all-important arm—the bayonet—was given by *Engineering* during the course of 1878, which states that it is an arm peculiarly French. It was invented, it is said, at Bayonne, in 1641, and employed in 1670 in the regiment of the King's Fusiliers. It sensibly modified the military art in Europe, as it made cavalry less terrible to infantry, and caused the fires of lines of battle to be regarded as the principal means of action. According to a local tradition, it was in a small hamlet near Bayonne that this arm was invented. What led to its invention was that, in a fierce combat between some Basque peasants and some Spanish smugglers, the former, having exhausted their ammunition, fastened their long knives to their muskets, and by means of the weapon so formed put their enemies to flight. The arm rapidly came into general use in Europe. In 1678, at the time of the peace of Nimeguen, all the French grenadiers had the bayonet, but the socket, which makes the use of it so easy, was not invented until a later period. Bayonets at that time were a sort of dagger, of which the handle was placed in the muzzle of the musket, and, of course, prevented the musket from being fired. The first battle at which the bayonet was seriously used was that of Turin, in 1682; but it was not till the battle of Spires, 1703, that the first bayonet charge was executed.

XXIV.—ASTRONOMY.

The Scintillation of Stars.—The scintillation of stars continues to occupy M. Montigny's attention, and in a paper furnished in 1878 to the Belgian Academy, he discusses a series of observations which seem fully to demonstrate that stars whose spectra are characterised by dark bands and black lines scintillate less than stars with fine and numerous spectral lines, and much less than those whose spectra present only a few of the principal lines. With regard to the colours in scintillation—which are principally red, orange, yellow, green, green-blue, blue, and violet—he mentions, interalia, that blue seems generally to predominate over the other colours in rainy weather. Red is the most constant type; green and violet are very rare, yellow is rarely absent, and orange is very frequently predominant.

The Moon's Atmosphere.—Professor Alexander brought forward at a Meeting, during the course of 1878, of the National Academy of Sciences, a variety of evidence, principally drawn from observations during eclipses, tending to indicate some envelope, like an atmosphere, for the moon. The explanations usually offered for the bright band seen around the moon at such times were fully considered and shown to be inadequate, though good as far as they would apply. The ruddy band of light is much too broad to be the sun's chromosphere. Various experiments proved that it was not a consequence of contrast alone. It was most apparent in those instances where the moon was nearest the earth. It could best be accounted for by supposing an atmosphere to the moon—a thin remnant of ancient nebulosity comparable to that which accompanies the earth and gives rise to the appearance of the aurora borealis.

Sun Spots.—Professor Wolf, of Zurich, has spent many years in collecting from every possible source records of sun-spots from the beginning of the seventeenth century, and the beginning of the telescope. And after careful examination he arrives at the conclusion that they do not bear out the theory of an eleven years' period, for since 1610 there are 20 or 30 different maxima and minima, extending to 16 years in some instances, and in others contracting to seven years. This is a fresh proof that many more observations are required for a settlement of the question.

London Institution.—A lecture was delivered early in 1878, at the London Institution, on "Recent additions to our knowledge of Shooting Stars," by Prof. Ball, the Astronomer Royal for Ireland. The lecturer reminded his hearers that besides the stars we see on a clear night, and besides those the telescope makes known, there are

countless bodies moving through space which even the most powerful telescope fails to reveal, till they come either in the orbit of the earth or of its atmosphere. These are what are called meteorites and shooting stars, and it is important to distinguish clearly between the two. They are alike luminous from the same cause, that of friction in passing through the atmosphere, though but few people have ever seen a meteorite falling. The number of shooting stars is infinitely greater than is usually supposed, for observers with telescopes often see them flash across the field in dimensions too small to be seen with the naked eye. We know that shooting stars undergo combustion in passing through our atmosphere. What becomes of the *debris?* The snow of the Alps, far away from furnaces, contains globules of iron, and dust that has quietly accumulated in exposed places contains them also. It is supposed they represent some of the *debris*. Though we may grumble at our atmosphere in bad weather, we must recollect it, at least, does this, it burns up these bodies that are pelting down upon us at a rate 100 times greater than the missile of an 81-ton gun, and, but for this burning up, they would be at any rate awkward for us. In looking at the knowledge accumulated with regard to shooting stars, the first point to notice, Professor Ball says, is that certain great showers are periodical, and always come from the same parts of the heavens. According to the constellation from which they appear to come, they are called Lyraids, Perseides, Orionids, Leonids, &c. The inference from these recurring periods is that the orbit of the earth then cuts the orbit in which a mass of these is moving. With this fact of recurrence it must be noticed that certain comets are periodical, and from a comparison of their supposed orbits with those of groups of these bodies, a connexion between them is inferred, whatever may be the origin of the comets, which is not yet known. Meteorites, on the contrary, are never known to come from the direction of a comet path. If a meteorite is carefully examined, it is seen to be a fragment of some rock, and that of one closely analogous to our earth's volcanic rocks. If we consider in turn the volcanic sources from which they could have come, we see the sun would have force enough to drive off fragments ; but it is hardly likely that there are solid rocks there to drive off. Jules Verne is right, Professor Ball says, in calculating that a body driven up from the earth with a force equal to six miles a second would not return. From Ceres three miles a second would be sufficient. Examining all the planets in turn, it seems improbable that the meteorites originate from any of them. It seems much more likely that they were in former times of greater volcanic activity driven up from the earth itself, and they again, after lapse of ages, meet the earth in its orbit. The theory that they come in from unlimited space is, Professor Ball thinks, highly improbable.

The Condition of Mars.—In a paper read, during the course of 1878, at a Meeting of the Royal

Astronomical Society, Mr. Brett argues against the hypothesis that Mars is in a condition similar to that of the earth. He grounds his conclusion on the fact that in all his observations of Mars he has seen no clouds in the atmosphere thereof. The atmosphere is very dense, of great bulk, and is probably of a temperature so high that any aqueous vapour contained therein is prevented from condensation. Mr. Brett implies that the glowing red colour of the middle of the disk is glowing red heat; and he remarks, "In terrestrial experience there is always an intermediate phenomenon between vapour and snow, namely opaque cloud; and the absence of this condition seems fatal to the hypothesis that the white polar patch, as hitherto supposed, consists of snow." According to Mr. Brett this patch is not only not snow; constitutes no part of the solid mass of the planet; but is nothing more than a patch of cloud, "the only real cloud existing in Mars."

The Moons of Mars.—Planetary satellites are a characteristic of our solar system; and now that the able astronomers at Washington have shown that Mars has two moons, that mythological deity ceases to be exceptional. Neither in rate of motion nor in distance from the planet is there agreement between the two; for we are informed by Mr. Christie of the Greenwich Observatory, that "the outer satellite revolves once in less than a day and a quarter, and the inner three and a quarter times in one day. The phenomena," he continues, "presented to an inhabitant of Mars must be very remarkable, for the outer satellite will remain above the horizon for two and a half days and nights, and the inner will rise in the west and set in the east twice in the course of the night. The lunar method of determining longitudes must be singularly easy with such a rapidly-moving satellite, which is equivalent to the addition of a minute-hand to the celestial clock, which in our case has to be read by the hour-hand alone."

Mr. Christie tells us further that the two moons have been seen by observers at Greenwich, Paris, and other places; and he remarks, that if they "have been in existence for ages, it seems strange that they have not been discovered before, especially at the opposition of 1862, when Mars approached the earth as closely as this year; but it is naturally much easier to see an object that has once been found than to discover it independently. The satellites must be much smaller than any of the minor planets hitherto discovered. Can Mars have picked up a couple of very large meteorites, which have approached him closely?"

Leaving this question to the experts, we add, in passing from the subject, that the orbital velocity of one of the moons is 79 miles a minute; of the other, 50 miles; and that their discovery has enabled astronomers to determine the mass of Mars, and thus settle what has been to them an important and long-standing problem. — *Chambers's Journal.*

The Nebular Hypothesis.—In a communication to the *Ameri-*

can Journal, Professor Kirkwood discusses the question—Does the motion of the inner satellite of Mars disprove the nebular hypothesis? "This satellite," he remarks, "is within three thousand four hundred miles of the planet's surface, and completes three orbital revolutions in less than a Martial day. How is this remarkable fact to be reconciled with the cosmogony of Laplace?" The Professor then remarks that there is some similarity between the movements of the satellites and those of the rings of Saturn. The rings are composed of clouds of exceedingly minute planetoids, and while the outer ring revolves in a period somewhat greater than that of Saturn itself, "the inner visible edge of the dusky ring completes a revolution in about eight hours." These rings, in the words of Professor Tait, like everything cosmical, must be gradually decaying because in the course of their motion round the planet there must be continual impacts among the separate portions of the mass; and of two which impinge one may be accelerated, bu expense of the other. Th falls out of the race, as and is gradually drawn in t the planet. The consequ that, possibly not so much count of the improvem telescopes of late years, b haps simply in consequenc gradual closing in of th system, a new ring of Sat been observed inside the ones, called from its app the crape ring, which was when first observed, but dually becoming broader. crape ring is formed of t gards which have been out of the race, and are gr falling in towards Saturn face. It is then suggeste by a process similar to th described, the phenonema Martial system may hav produced, and the argume cludes thus: "Unless som explanation as this can b the short period of th satellite will doubtless be r as a conclusive argument the nebular hypothesis."

XXV.—EXHIBITIONS OF THE YEAR.

The Paris Universal Exhibition.—So far as exhibitions were concerned, the Universal Exhibition of Paris was the great event of 1878. It was thrown open to the public on the 1st of May by the President of the French Republic, in presence of a large assembly of illustrious visitors. A general description of the plan of the exhibition and its principal buildings may here be given; the reader will find it a record of a colossal effort—"un effort de redressement superbe," says a foreign writer; and really it is marvellous that France, after all she has undergone, should yet have energy left for such a gigantic enterprise.

The space occupied by this exhibition was divided into two unequal parts by the Seine, one dominating the other. At the extreme end of the more elevated portion stood the Trocadéro Palace, which looked down on a sister construction in the Champ de Mars, on the other side of the river. The Trocadéro Palace was build of white stone, and consisted of a rotunda supported by columns, crowned by a dome not unlike that of the Invalides, and flanked by two lofty towers. On each side of the building extended a colonnade in the form of a semicircle, the rotunda boldly projecting forward. The object for which the Trocadéro Palace was especially destined was to serve as a lecture and concert-hall, and also to receive within its walls the members of the numerous learned societies and industrial congresses which assembled in Paris during the exhibition season.

Built by MM. Davioud and Bourdais, in a composite style of architecture, half Moorish, half Renaissance, the dome and glittering minarets of the Trocadéro Palace made it conspicuous for miles away. Its rotunda, which holds 7,000 persons, was the place where the inaugural ceremony was held and where the prizes were distributed. Flanking the rear of the rotunda and spreading in two shapely semicircles to right and left, were the wings, occupied by exhibits of glass, porcelain wares, and statuary. Terraces with colonnades fronted the wings, and overlooked the gardens, which sloped down to the river quay, as also the cascade and fountains, which descended from the foot of the rotunda and bisected the grounds. Eight large basins, surrounded by smaller ones, composed the reservoirs of this cascade, and each was provided with a giant water-spout. That of the broadest and lowermost basin threw up a jet to the height of 83 feet, splashing the colossal statues of the four beasts which adorned the pedestals at the basin's angles, viz.:—A bull, by M. Caïn; a horse, by Rouillart; a rhinoceros, by Jacquemart; and an elephant by Frémiet. The

rhinoceros, standing with his fore-paws elevated on a boulder of rock, was especially remarkable.

The mount or rising ground of the Trocadéro, as many of our readers will remember, obtained its name and fame as a public monument from the victory of a French military force, in 1823, employed to capture the Spanish fort of the Trocadéro in the harbour of Cadiz, for the suppression of a political revolt in the kingdom of Spain.

The Trocadéro was united to the Champ de Mars by an open iron-way thrown across the Pont de Jena; underneath which iron-way, and on the bridge of Jena itself, were placed the huge tubes which conveyed the waters of the Trocadéro cascade to artificial lakes in the park surrounding the palace of the Champ de Mars.

The length from the Trocadéro to the Ecole Militaire was 1,540 mètres, equal to about 1,684 yards, and the breadth 450 mètres, equal to 492 yards; the total ground covered by the various buildings, gardens, and courts, within the exhibition walls being thus 693,000 mètres, equal to 757,968 yards. The main building in the Champ de Mars covered 263,592 yards, being 765 yards in length, and 360 yards in breadth. The annexe buildings covered a considerable extent of ground, conspicuous among them being the principal English annexe, occupying a space of about 8,750 yards. The space appropriated to the English section in the main building was about 30,187 yards. Thus the English department, in point of extent, was by far the most important of the foreign sections, covering, with the annexe included, 38,937 yards.

Constructions in the two gardens of the Champ de Mars and the Trocadéro might be divided into four categories—first, official and administrative buildings; second, various annexes and pavilions belonging to foreign countries; third, buildings devoted to the reception of the products of French mechanical industry; and, fourth, restaurants, of which there were a great diversity, in ornamental buildings of various design and fashion.

The Champ de Mars Palace was approached by four main entrances. The Porte Tourville, on the right hand side of the Ecole Militaire, conducted the visitor into the heart of the French machinery department; Porte Dupleix, at the opposite angle on the left, led into the department of foreign machinery; Porte Dessaix and Porte Rapp, the former in the centre of the Avenue Suffren, and the latter in that of the Avenue de la Bourdonnaye, on the opposite side, were the direct routes to the fine-arts galleries. Portes Grenelle and of the Seine, situated at the two extremities of the Exhibition grounds bordering the river, were the best entrances by which a visitor could view with advantage the panorama presented by the two palaces, the garden, and the Seine.

The main Exhibition Building, in the Champ de Mars, was of quadrangular shape, and its front aspect, which was very light and graceful, bore the visible outward impress of its destiny—namely, the temporary sojourn of the treasures of art and the mani-

fold productions of civilisation. It was crowned by two figures of genii, below which were six emblematical statues of European nations, England being twice symbolised—first, as Britannia, and secondly, as a Colonial Power. Commencing from the Ecole Militaire, the Palace of the Champ de Mars was bisected by two long uncovered ways, which divided it, so to speak, into two nearly equal parts, the right being devoted to the products of French industry, and the left to those of foreign nations; the centre of these two parallel routes being occupied by the section of the fine arts of all nations. One of these lateral routes possessed a peculiar feature, presenting a specimen of the architecture of all the different foreign nations who had contributed to the Exhibition. The Prince of Wales's Indian pavilion stood first, followed by the severe but tasteful façade of a model factory: then came a row of pleasure villas, such as one might admire on the banks of the Thames about Richmond and Maidenhead; after which the United States, Sweden, Norway, and Italy successively showed their dwellings of brick or wood, and their palaces of marble. Japan, China, Spain, and Austria-Hungary might be studied next; then came Russia, with houses curiously painted; Switzerland, with cottages and dairies; Belgium, with fretted models of Flemish town-halls; then Greece, Denmark, South America, Morocco, Luxemburg and Monaco, Portugal and Holland—all in the order named. These houses stood to the right of the grand street, and the architectural sample of each nation formed the façade to the industrial and art sections which lay behind. The whole of the left side of the street and the left wing of the Exhibition building to the rear were occupied by French houses and by the French sections of exhibits, so that France alone had chartered a space equal to that of all other nations clubbed together. Among foreign countries England stood foremost, both for the extent and excellence of its productions.

The centre of the Palace erected on the Champ de Mars, bounded on each side by the bisecting ways described already, and cutting the Fine Arts Section in two, was a magnificent hall reserved for the city of Paris exhibitors. A long gallery ran across the front of the Palace facing the Trocadéro, one end of which was guarded by a bronze equestrian statue of Charlemagne, supported by two warriors grim and bearded, with battle-axe in hand; and at the other rose up, in all the glories of dome and cupola, an Indian temple abutting on the English section, where the magnificent Indian collection of the Prince of Wales was deposited. Following the precedent of former Exhibitions, the gallery of machinery formed the outer rim of the two sides of the building, and on the third side, facing the Ecole Militaire, was a gallery reserved for the exhibition of manual labour, where workpeople were engaged in pursuing their various callings under the eye of the spectator.

In addition to the large French gallery for machines was another vast gallery for the reception of foreign machines; England, Bel-

gium, and the United States, all great producers of machines, were prominently represented. The machines of other nations, less advanced in this branch of industry, were placed amongst their miscellaneous productions. The nine hectares (90,874 square mètres), originally allotted to them, were far from sufficing for the needs of foreign exhibitors.

In the English section of the Exhibition the contributors numbered more than 1,500, London and its suburbs contributing about 700; Manchester, 64; Birmingham, 56; Glasgow, 43; Leeds, 40; Edinburgh, 38; Sheffield, 35; Dublin, 28; Huddersfield, 24; Liverpool, 22; Bradford, 18; Belfast, 17; Norwich, 16; Bristol, 15; and Nottingham, 13. Some classes were crowded, while others were all but empty, or even entirely so. There were 31 brewers and distillers among the exhibitors. Vegetables and fruits had only one entry, which proceeded from Edinburgh. Paper-hangings, shawls and flowers, and ornamental plants, had only three each; cutlery, five: maps, travelling apparatus, and camp equipage, military materials and apparatus, six each. At the other end of the scale, mining and metallurgy had 108 entries; chemical and pharmaceutical products, 89; civil engineering apparatus, 81; machines and apparatus in general, 79; woollen yarn and fabrics, 69; agricultural implements, 68; navigation and life-saving apparatus, 45; clothing, 44; agricultural and food-making apparatus, 41. Taking the broader demarcation of groups, mechanical apparatus and processes muster 530 exhibitors; textile fabrics, 292; furniture and accessories, 244; mining industries and raw and manufactured products, 241; education and liberal art processes, 208; alimentary products, 98; and horticulture, 25. In the fine art group there were 283 oil paintings, 191 water colours and drawings, 46 sculptures, 171 architectural drawings and models, and 42 engravings and lithographs.

The exhibition, by good fortune, could be reached either by tramway, or railway, or by the Seine. At the stations of all the trunk lines of railway tickets were granted for the exhibition, the passengers being forwarded to their destination by the circular railway without any additional expense.

The exact cost of constructing the Exhibition was announced to have been 45,300,000f., being 10,000,000f. in excess of the original estimate; an excess due to enlargement of plans and the resolution to make the Trocadéro a permanent building.

The Exhibition closed at 5 p.m. on Sunday, November 10th. Notwithstanding the keen wind and sombre sky, there was an attendance of 130,000 visitors, half of that number, however, being free admissions. The gross receipts from the 1st of May were 12,653,746f., against 9,830,369f. in 1867. 140,000f. was paid for admissions before the opening and after the close, and 700,000f. for extra charges; sources of revenue not existing in 1878. Moreover, in 1867, there were only 400,000 free admissions; there were in 1878, 950,000: and the

artisan delegates from the provinces numbered 22,000 in 1878, as compared with 354 in 1867. The grand total of admissions was 16,032,725, being an average of about 82,000 per day.

The following statistics relating to previous exhibitions, which we draw from *Deutsch Ind. Zeitung*, will be found of interest:—The London Exhibition of 1851 numbered 13,917 exhibitors, and was visited during 142 days by 6,099,194 persons; the Paris Exhibition of 1855 had 24,954 exhibitors, was open 200 days, and visited by 5,121,330 persons; the London Exhibition of 1862, 28,650 exhibitors, 176 days, 6,211,103 visitors; the Paris Exhibition of 1867, 50,226 exhibitors, 210 days, 10,200,000 visitors; the Vienna Exhibition of 1873, 42,584 exhibitors, 186 days, 7,254,687 visitors; the Philadelphia Exhibition of 1876, 159 days, and 9,857,625 visitors.

The awards accorded to each nation have been thus summarized:— The silver and bronze medals and honourable mentions argued quantity rather than quality. The best criterion of the latter, assuming that the judges had been fairly accurate, or that, internationally, their mistakes neutralised each other, was the number of grand prizes and gold medals. Of these, France carried off 1984; England and her colonies, 369; Austria-Hungary, 252; Belgium, 184; Spain, 167; Italy, 157; United States, 145; Russia, 123; Switzerland, 86; Holland, 70; Sweden and Norway, 70; the French colonies, 57; Denmark, 27; Greece, 12. As to the distinctions of all kinds, France, of course, stood first, with 13,569; Spain and her colonies coming next, with 2,500; England and her colonies, third, with 2,455; and Austria fourth, with 1,770. The Spanish aggregate exceeded the English by reason of a larger number of minor awards—viz., 829 bronze medals and 964 honourable mentions, as compared with 779 and 647.

A Paper Exhibition.—A Paper Exhibition was held in Berlin during the course of 1878, and an instructive variety of objects was exhibited—from flimsy to paper carpets, chairs, and even boats. Both the articles manufactured and the materials, chemical and other, connected with the manufacture of paper, were exhibited. The following interesting statistics regarding the consumption of paper are obtained from the Catalogue:—

	Number of Inhabitants.	Kilos consumed.	Kilos per head.
United States	39,000,000	535,000,000	14·0
Germany ...	43,000,000	244,000,000	6·0
England ...	33,000,000	163,000,000	5·0
France... ...	37,000,000	138,000,000	3·6
Austria-Hungary	36,000,000	92,000,000	2·5
Russia	27,000,000	67,000,000	0·9
Italy	28,000,000	38,000,000	1·4
Scandinavia	6,000,000	3,000,000	0·5
Belgium ...	5,500,000	27,000,000	5·1
Switzerland	2,500,000	17,000,000	6·3

According to inscriptions put up in the hall of the Exhibition, and illustrated by paste-board cubes of different size, 600,000,000 men employ Chinese paper, while 366,000,000 use the European, and 130,000,000 the Arabian article; 24,000,000 write on leaves, bark, and wood, 280,000,000 dispensing with writing and reading, and consequently taking no interest in this enlightened exhibition.

XXVI.—MISCELLANEOUS.

Living on a Trifle per Day.—The question of how little food is sufficient to support life has been studied by an Indian doctor, in the most practical manner, the doctor having subjected himself to a diet experiment for six weeks. In support of his theory that a man's daily food should only cost him sixpence, the doctor lived for the first seven days on bread, milk, fruit, and vegetables, costing only 3*s*. 1*d*., and having an average daily weight of a little over half a pound. His health remained perfect and his weight did not diminish, so for the second week he took prepared farinaceous food, milk, and fruit, consuming daily a little over 9½ oz., and then felt so strong that he gave up milk and lived on 3*d*. a day. In the fourth week he took half a pound of food daily, at a cost of 2*d*., and tried soup, puddings, and eggs, but this did not answer, and for the fifth and sixth weeks he lived on 8¾ oz. to 9 oz. daily. He carefully avoided stimulants and tobacco, and finally declared that he experienced a constant increase of physical strength and power of work.

How to Render Corks Air and Water Tight.—The *Chem. Zeitung* suggests the use of paraffin as the best method of making porous corks gas and water tight. Allow the corks to remain for about five minutes beneath the surface of melted paraffin in a suitable vessel, the corks being held down either by a perforated lid, wire screen, or similar device. Corks thus prepared can be easily cut and bored, have a perfectly smooth exterior, may be introduced and removed from the neck of a flask with ease, and make a perfect seal.

Safety for Post Office Packages.—The postal wrappers and envelopes in common use can, of course, be easily opened by loosening the gum with moisture. Postage stamps can, in the same way, be dishonestly detached. The object of a recent American patent, by Mr. Fox, of Baltimore, is to meet this evil. Two adhesive compounds are used—one is applied to the flap, the other to the part against which this is pressed. The latter, which is not touched with the lips or the tongue, is prepared thus:—About 2·5 gr. crystallised chromic acid is dissolved in 15 gr. water and 15 gr. ammonia. To this mixture are added about 10 drops of sulphuric acid, and 30 gr. of sulphate of cupric oxide-ammonia, as also 4 gr. fine white paper. The other solution, for the flap (which is moistened with the mouth), is obtained by dissolving is in-glass in dilute acetic acid (1 part acid to 7 parts water) over

the water bath. When the parts of the wrapper, &c., are fastened together, the union is so firm as to resist all loosening influences, acids, alkalies, hot or cold water, or steam; the wrapper can only be opened by tearing or cutting.

The Apparatus of Electric Lighting.—Some of the more interesting portions of the apparatus of electric lighting are shown in our frontispiece. One figure represents the Jablochkoff candle, which consists of a pair of carbon rods, *a* and *a*, each nine inches long and a trifle over three-sixteenths of an inch in thickness. The pair are connected at the top by a short piece of carbon, but are, throughout their length downward, insulated respectively by an intervening composition of china clay, *b*. The lower end of each carbon is inserted in a brass tube, *c*, which is the socket by which it stands in the chandelier, also shown in the frontispiece. (*See* the Year Book of Facts for 1877.) The Gramme machine and the Wallace machine, represented by the artist, are machines employed for generating the electricity with which the light is fed. The latter machine is the one most in use in the United States; the former is that chiefly employed in this country. The Gramme machine is the invention of a Parisian workman. Its principle—a principle which involves many abstruse questions of electric currents—is that of an induction coil having for its core a ring or cylinder of soft iron, and revolving mechanically between two round bars, each of which is the core of a pair of electro-magnets.

Superstitions about "Thunderstones."—An interesting work, entitled "L'Age de Pierre dans les Souvenirs et Superstitions Populaires," was published, early in 1878, by M. Emile Cartailhac. M. Cartailhac has collected instances of the use of flint implements as amulets and instruments of superstition, and the references to such use in classic and other authors. His conclusions are that in our own days, in the Middle Ages, in antiquity, and in all countries, a "thunderstone," or similar venerated object, has proved, in nearly every instance that can be verified, to be a stone hatchet or a stone arrow-head, a relic of the first inhabitants of the country. Superstition availed herself of such relics because the history of the stone age had been lost. While, in the lands of classic antiquity, the use of certain stone instruments survived in some cases, that was in consequence only of the conservative spirit of religion; proof of the prolongation of an age of stone among a people in contact with advanced civilisation is vainly to be looked for, the stone implements found in connection with remains of nations expert in the use of metals being accounted for by the superstitious ideas which had become attached to them. The age of stone was, in fact, a first state of civilization of which humanity everywhere retains a more or less unconscious tradition. These views are supported by a reproduction of the illustrations to Mahudel's remarkable memoir on pretended thunderstones, read in 1740 before the French Academy, and by many

other illustrations and quotations.

Is the Brain a Phonograph?—Speaking recently at the Society of Telegraph Engineers, Dr. C. W. Siemens "ventured to draw an analogy between the action of the phonograph and the action of the brain in the exercise of memory," and in *Nature*, for May 30, 1878, he enlarged upon his speculation to the extent of making his reasoning clear enough to submit it to the critical test. All impressions received by us from without, either through the tympanum of the ear, the retina of the eye, or through the sensitive nerves of the skin, are, it is generally believed by physiologists, communicated to corpuscular bodies in the brain, which lie imbedded in a grey substance, the nature and precise function of which have not yet been fully explained. It would appear that the corpuscular bodies in which the sensitive nerves terminate are connected, through the medium of extremely delicate filaments, with the nervous system of volition, the reaction of the one system upon the other being attributable to mental energy. It may be conceived that any fresh impressions received on the extremely complex sensitive network of the brain may give rise, then and there, to acts of volition; but how, it may be asked, can acts of volition arise from impressions that were communicated through the sensitive nerves years before, having been committed in the meantime to what we term the memory? But in order that the mind can deal with an impression previously received it seems necessary that *it must* have the power of reproducing the same from some material record by which the impression has been rendered permanent. Take the case of a tune that we have heard in early youth and which may not have since recurred to us. By some incident or other that tune and the words connected with it become suddenly revivified in the mind. If the tune had been sung into a phonograph it could have been reproduced at any time by releasing a spring moving the barrel of the instrument; and it seems a fair question to ask whether the gray substance of the brain may not, after all, be something analogous to a storehouse of phonographic impressions representing the accumulated treasure of our knowledge and experience, to be called into requisition by the directing power of the mind in turning on, as it were, one barrel or another.

Such a hypothesis might possibly serve also to explain how in sleep, when the directing power of the mind is not active, a local disturbance in the nervous system may turn on one or more phonographic barrels at a time, and thus produce the confused images of dreamland! A powerful mind would exercise a complete control over the innumerable barrels constituting our store of knowledge, whereas in a weak mind the impressions of the past would be brought back into evidence in a confused and irregular manner. Such a supposition might also account for the more vivid recollection of impressions received in early life, when the mechanical record stored up in the brain may be supposed to have been more

distinctly and indelibly rendered. In speaking of these impressions as phonographic, it does not follow that they were originally conveyed through the tympanum of the ear. Mr. Willoughby Smith, at the meeting above referred to, called attention to the fact that, by substituting crystalline selenium for carbon in the microphone, a ray of sunlight directed upon the selenium produces a noise comparable with that produced by a Nasymth hammer; and it is quite feasible that the impressions received through the retina of the eye, and the nervous system generally, would be equally susceptible of being recorded in the cerebral storehouse. The record itself might be supposed to be of a mechanical, or, more probably, of a molecular character, the one thing important being that it must be material. These observations are, no doubt, extremely crude, but may serve possibly to direct the attention of physiologists to a point of interest to their science; nor would it be the first occasion on which a phenomenon of inanimate nature had revealed the secrets of animate organisation.

Health and Education.—Dr. B. W. Richardson delivered a lecture during the month of January, 1878, at the London Institution, on "Learning and Health." After describing, in his introductory remarks, excessive specialization on the part of men of science and members of learned professions, Dr. Richardson said he trusted some scholar would declare the unity of knowledge, and denounce from the point of view of education the subdivision of knowledge into minute departments, out of which the student dared not step. To him it fell to oppose the system as destructive to vital activity, and thereby to the strength of mental growth. It was his business to declare that at this time health and education were not going hand in hand. He could not sit day by day to see the failure of the young brain, and of the brain approaching its maturity, and of the brain matured, and tamely accept the phenomena as inevitable. To him, observing as a physician, the appearance now-a-days of such men as Shakespeare, Reynolds, Kemble, Newton, Bacon, Scott were, in the freedom of their intellectual growths, was impossible. Nature could, as of old, produce acorns for future oaks, but if the young oaks were forced in their growth, and when approaching maturity were barbarously compressed into narrow and unyielding tubes, there would be no forest.

The present modes of education are not compatible with healthy life. Faults in construction of schoolrooms, in school discipline, and school punishment exist, but they are departing errors. In their time they hardened many hearts and broke more, and have left their impress on the men and women whom they trained into transmissible forms of character and mind.

The first serious and increasing evil bearing on education and its relation to health lies in the too early subjection of pupils to study. Children are often taught lessons from books before they are properly taught to walk and long before they are properly taught to

play. Play is held out to them not as a natural thing, as something which the parent should feel it a duty to encourage, but as a reward for so much work done and as a rest from work done, as though play were not itself a form of work, a form of work which a child likes while he dislikes another form because it is unfitted to his powers. For children under seven years of age all teaching should be through play. Through play letters and languages can be taught, animal life can be classified, and the surface of the earth made clear, and history can be told as a story. Under such a system the child grows into knowledge, learns well, eats, sleeps, and plays well, and acquires the habit of happiness. The increase of garden schools is a good sign.

There are schools where children of eight, nine, and ten years of age, or it may be younger, are made to study from nine o'clock until noon, and again, after a hasty meal and an hour for play, from two to five, and later on are obliged to prepare lessons for the following morning. The brain is rendered active because diverted from its natural course; the child becomes precocious. Its tongue will be furred or covered with many red points like a strawberry, or too red and very dry. The appetite is capricious, strange foods are asked for, and the stomach is never in order. If you watch the face you note that the frequent flush gives way to paleness. The eyes gleam with light at one time, and are dull and sad at another. The sleep is broken. The child is a victim to the intemperance of education.

Dr. Richardson passed on to speak of overwork and unhealthy competition at a somewhat later age, observing that to put a horse in harness and make it work hard while growing is acknowledged to be cruel and ignorant, but that to make a growing child work hard is thought a mark of vigilance. Teachers are often forced into such a course by the ambition of parents. The physician sees the result of the excitement of success and the depression after failure. Young men and young women now who are presenting themselves for the higher class examinations are crushed by the intensity of the effort. In the past year four of these victims had been under the lecturer's care. In one, absence of memory had resulted; in another, sleeplessness, and that exhaustion which leads almost to delirious wandering. Here failure caused extreme depression. In the third case sleeplessness, labour, and excitement brought on an hereditary tendency to intermittency of the action of the heart. The examiners were not testing the cramming of this youth: he failed because his heart could hold out no longer under their manipulation.

XXVII.—THE BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS.

Delivered by WILLIAM SPOTTISWOODE, *Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., at Dublin, on the* 14*th of August*, 1878.

On looking back at the long array of distinguished men who both in this and in the sister countries have filled the chair of the British Association, on considering also the increased pains which have been bestowed upon, and the increased importance attaching to the presidential address, it may well happen when, as on this occasion, your choice has fallen upon one outside the sphere of professional science, that your nominee should feel unusual diffidence in accepting the post. Two considerations have, however, in my own case outweighed all reasons for hesitation—first, the uniform kindness which I received at the hands of the association throughout the eight years during which I had the honour of holding another office; and, secondly, the conviction that the same goodwill which was accorded to your treasurer would be extended to your president.

These considerations have led me to arrange my observations under two heads—viz., I propose first to offer some remarks upon the purposes and prospects of the association with which, through your suffrages, I have been so long and so agreeably connected; and, secondly, to indulge in a few reflections, not indeed upon the details or technical progress, but upon the external aspects and tendencies of the science which on this occasion I have the honour to represent. The former of these subjects is, perhaps, trite; but as an old man is allowed to become garrulous on his own hobby, so an old officer may be pardoned for lingering about a favourite theme. And although the latter may appear somewhat unpromising, I have decided to make it one of the topics of my discourse, from the consideration that the holder of this office will generally do better by giving utterance to what has already become part of his own thought than by gathering matter outside of its habitual range for the special occasion. For, as it seems to me, the interest (if any) of an address consists not so much in the multitude of things therein brought forward as in the individuality of the mode in which they are treated.

The British Association has already entered its fifth decade. It has held its meetings, this the 48th, in 28 different towns. In six cities of note—viz., York, Bristol, Newcastle-on-Tyne, Plymouth, Manchester, and Belfast, its curve of progress may be said to have a node, or point through which it has twice passed; in the

five Universities of Oxford, Cambridge, Dublin, Edinburgh, and Glasgow, and in the two great commercial centres, Liverpool and Birmingham, it may similarly be said to have a triple point, or one through which it has three times passed. Of our 46 presidents more than half (26 in fact) have passed away; while the remainder hold important posts in science and in the public service, or in other avocations not less honourable in themselves, nor less useful to the commonwealth. And whether it be due to the salubrity of the climate or to the calm and dispassionate spirit in which science is pursued by its votaries here, I do not pretend to say; but it is a fact that the earliest of our ex-presidents still living, himself one of the original members of the association, is a native of and resident in this country.

At both of our former meetings held in Dublin, in 1835 and 1857 respectively, while greatly indebted to the liberal hospitality of the citizens at large, we were, as we now are, under special obligations to the authorities of Trinity College for placing at our disposal buildings, not only unusually spacious and convenient in themselves, but full of reminiscences calculated to awake the scientific sympathies of all who may be gathered in them. At both of those former Dublin meetings the venerable name of Lloyd figured at our head; and if long established custom had not seemed to preclude it, I could on many accounts have wished that we had met for a third time under the same name. And although other *distinguished* men, such as Dr. Robinson, Professors Stokes, Tyndall, and Andrews, are similarly disqualified by having already passed the presidential chair, while others again, such as Sir W. R. Hamilton, Dr. M'Cullagh, and Professor Jukes, are permanently lost to our ranks, still we should not have had far to seek had we looked for a president in this fertile island itself. But as everyone connected with the place of meeting partakes of the character of host towards ourselves as guests, it has been thought by our oldest and most experienced members that we should better respond to an invitation by bringing with us a president to speak as our representative than by seeking one on the spot; and we may always hope on subsequent occasions that some of our present hosts may respond to a similar call.

But leaving our past history, which will form a theme most appropriate to our jubilee meeting in 1881, at the ancient city of York, I will ask your attention to a few particulars of our actual operations. Time was when the Royal Societies of London and Edinburgh and the Royal Irish Academy were the only representative bodies of British science and the only receptacles of memoirs relating thereto. But latterly, the division of labour, so general in industrial life, has operated in giving rise to special societies, such as the Astronomical, the Linnæan, the Chemical, the Geological, the Geographical, the Statistical, the Mathematical, the Physical, and many others. To both the earlier or more general, and the later or more special societies alike, the British Asso-

ciation shows resemblance and affinity. We are general in our comprehensiveness; we are special in our sectional arrangement; and in this respect we offer not only a counterpart, but to some extent a counterpoise, to the general tendency to subdivision in science. Further still, while maintaining in their integrity all the elements of a strictly scientific body, we also include, in our character of a microcosm, and under our more social aspect, a certain freedom of treatment, and interaction of our various branches, which is scarcely possible among separate and independent societies.

The general business of our meetings consists, first, in receiving and discussing communications upon scientific subjects at the various sections into which our body is divided, with discussions thereon; secondly, in distributing under the advice of our committee of recommendations the funds arising from the subscriptions of members and associates; and, thirdly, in electing a council upon whom devolves the conduct of our affairs until the next meeting.

The communications to the sections are of two kinds—viz., papers from individuals and reports from committees. As to the subject-matter of the papers, nothing which falls within the range of natural knowledge, as partitioned among our sections, can be considered foreign to the purposes of the association; and even many applications of science, when viewed in reference to their scientific basis, may properly find a place in our proceedings. So numerous, however, are the topics therein comprised, so easy the transition beyond these limits, that it has been thought necessary to confine ourselves strictly within this range, lest the introduction of other matters, however interesting to individual members, should lead to the sacrifice of more important subjects.

As to the form of the communications, while it is quite true that every scientific conclusion should be based upon substantial evidence, every theory complete before being submitted for final adoption, it is not the less desirable that even tentative conclusions and hypothetical principles when supported by sufficient *primâ facie* evidence, and enunciated in such a manner as to be clearly apprehended, should find room for discussion at our sectional meetings. Considering, however, our limitations of time, and the varied nature of our audience, it would seem not inappropriate to suspend, mentally if not materially, over the doors of our section rooms, the Frenchman's *dictum*, that no scientific theory "can be considered complete until it is so clear that it can be explained to the first man you meet in the street."

Among the communications to the sections, undoubtedly the most important, as a rule, are the reports—that is to say, documents issued from specially appointed committees, some of which have been recipients of the grants mentioned above. These reports are in the main of two kinds—first, accounts of observations carried on for a series of years, and intended as records of information on the special subjects; such, for instance, have been

those made by the Kew Committee, by the committees on luminous meteors, on British rainfall, on the speed of steamships, on underground temperature, on the exploration of certain geological caverns, &c. These investigations, frequently originating in the energy and special qualifications of an individual, but conducted under the control of a committee, have, in many cases, been continued from year to year, until either the object has been fully attained or the matter has been passed into the hands of other bodies, which have thus been led to recognize an inquiry into these subjects as part and parcel of their appropriate functions.

The second class is one which is, perhaps, even more peculiar to the association—viz., the reports on the progress and present state of some main topics of science. Among these may be instanced the early reports on astronomy, on optics, on the progress of analysis; and, later, those on electrical resistance, and on tides; that of Professor G. G. Stokes on double refraction; that of Professor H. J. Smith on the theory of numbers; that of Mr. Russell on hyperelliptic transcendents, and others. On this head Professor Carey Foster, in his address to the Mathematical and Physical section at our meeting last year, made some excellent recommendations, to which, however, I need not at present more particularly refer, as the result of them will be duly laid before the section in the form of the report from a committee to which they were referred. It will be sufficient *here to* add that the wide extension of the sciences in almost every branch and the consequent specialization of the studies of each individual have rendered the need of such reports more than ever pressing; and if the course of true science should still run smooth it is probable that the need will increase rather than diminish.

If time and space had permitted, I should have further particularized the committees, occasionally appointed, on subjects connected with education. But I must leave this theme for some future president, and content myself with pointing out that the British Association alone among scientific societies concerns itself directly with these questions, and is open to appeals for counsel and support from the great teaching body of the country. One of the principal methods by which this association materially promotes the advancement of science, and consequently one of its most important functions, consists in grants of money from its own income in aid of special scientific researches. The total amount so laid out during the 47 years of our existence has been no less than £44,000; and the average during the last ten years has been £1,450 per annum. These sums have not only been in the main wisely voted and usefully expended, but they have been themselves productive of much additional voluntary expenditure of both time and money on the part of those to whom the grants have been intrusted. The results have come back to the association in the form of papers and reports, many of which have been printed in our volumes. By

this appropriation of a large portion of its funds, the association has to some extent anticipated, nay, even it may have partly inspired the ideas now so much discussed, of the endowment of research; and whether the aspirations of those who advocate such endowment be ever fully realized or not, there can, I think, be no doubt whatever that the association, in the matter of these grants, has afforded a most powerful stimulus to original research and discovery.

Regarded from another point of view these grants, together with others to be hereafter mentioned, present a strong similarity to that useful institution, the Professoriate Extraordinary of Germany, to which there are no foundations exactly corresponding in this country. For besides their more direct educational purpose, these professorships are intended, like our own grants, to afford to special individuals an opportunity of following out the special work for which they have previously proved themselves competent. And in this respect the British Association may be regarded as supplying to the extent of its means an elasticity which is wanting in our own Universities. Besides the funds which through your support are at the disposal of the British Association, there are, as is well known to many here present, other funds of more or less similar character at the disposal or subject to the recommendations of the Royal Society. There is the donation fund the property of the society, the Government grant of £1,000 per annum, administered by the society, and the Government fund of £4,000 per annum (an experiment for five years), to be distributed by the science and art department, both for research itself and for the support of those engaged therein, according to the recommendations of a committee consisting mainly of Fellows of the Royal Society. To these might be added other funds in the hands of different scientific societies. But, although it must be admitted that the purposes of these various funds are not to be distinguished by any very simple line of demarcation, and that they may therefore occasionally appear to overlap one another, it may still, I think, be fairly maintained that this fact does not furnish any sufficient reason against their coexistence. There are many topics of research too minute in their range, too tentative in their present condition, to come fairly within the scope of the funds administered by the Royal Society. There are others ample enough in their extent, and long enough in their necessary duration, to claim for their support a national grant, but which need to be actually set on foot or tried before they can fairly expect the recognition either of the public or of the Government. To these categories others might be added; but the above-mentioned instances will, perhaps, suffice to show that even if larger and more permanent funds were devoted to the promotion of research than is the case at present, there would still be a field of activity open to the British Association as well as to other scientific bodies which may have funds at their disposal.

On the general question it is not difficult to offer strong arguments in favour of permanent national scientific institutions; nor is it difficult to picture to the mind an ideal future when science and art shall walk hand in hand together, led by a willing minister into the green pastures of the endowment of research.[1]

But while allowing this to be a no impossible future, we must still admit that there are other and less promising possibilities, which under existing circumstances cannot be altogether left out of our calculations. I am, therefore, on the whole inclined to think that, while not losing sight of larger schemes, the wisest policy, for the present, at all events, and pending the experiment of the Government fund, will be to confine our efforts to a careful selection of definite persons to carry out definite pieces of work, leaving to them the honour (or the *onus*, if they so think it) of justifying from time to time a continuation of the confidence which the Government or other supporting body may have once placed in them.

[1] It is worth while to compare the following passage from Plato's "Republic," Book vii. (Jowett's translation):—

"'After plane geometry, we took solids in revolution instead of taking solids in themselves; whereas after the second dimension, the third, which is concerned with cubes and dimensions of depth, ought to have been followed.'

"'It is true, Socrates; but these subjects seem to be as yet hardly explored.'

"'Why, yes,' I said, 'and for two reasons; in the first place, no Government patronizes them, which leads to a want of energy in the study of them, and they are difficult; in the second place, students cannot learn them unless they have a teacher. But then a teacher is hardly to be found, and even if one could be found, as matters now stand the students of these subjects, who are very conceited, would not mind him; that, however, would be otherwise if the whole State patronized and honoured them; then they would listen, and there would be continuous and earnest search, and discoveries would be made; since even now, disregarded as they are by the world, and maimed of their fair proportions, and although none of their votaries can tell the use of them, still these studies force their way by their natural charm, and very likely they may emerge into light.'"

Passing from the proceedings to other features and functions of our body, it should be remembered that the continued existence of the association must depend largely upon the support which it receives from its members and associates. Stinted in the funds so arising, its scientific effectiveness would be materially impaired; and, deprived of them, its existence would be precarious. The amount at our disposal in each year will naturally vary with the population, with the accessibility, and with other circumstances of the place of meeting; there will be financially, as well as scientifically, good years and bad years. But we have in our invested capital a sum sufficient to tide over all probable fluctuations, and even to carry us efficiently through several years of financial famine, if ever such should occur. This seems to me sufficient; and we have, therefore, I think, no need to increase our reserve, beyond, perhaps, the moderate addition which a prudent treasurer will always try to secure against expenditure, which often increases and rarely diminishes. But however important this material support may be to our existence and well being, it is by no means all that is required.

There is another factor which enters into the product—namely,

the personal scientific support of our best men. It is, I think, not too much to say, that without their presence our meetings would fail in their chief and most important element, and had best be discontinued altogether. We make, it must be admitted, a demand of sensible magnitude in calling upon men who have been actively engaged during a great portion of the year, at a season when they may fairly look for relaxation, to attend a busy meeting and to contribute to its proceedings: but unless a fair quota at least of our veterans and a good muster of our younger men put in their appearance, our gatherings will be to little purpose. There was a period within my own recollection when it was uncertain whether the then younger members of our scientific growth would cast in their lot with us or not, and when the fate of the association depended very much upon their decision. They decided in our favour; they have since become presidents, lecturers, and other functionaries of our body, with what result it is for you to judge.

Of the advantages which may possibly accrue to the locality in which our meetings are held it is not for us to speak; but it is always a ground for sincere satisfaction to learn that our presence has been of any use in stimulating an interest or in promoting local efforts in the direction of science.

The functions of the British Association do not, however, terminate with the meeting itself. Besides the special committees already mentioned, there remains a very important body, elected by the general committee—viz., the council, which assembles at th office in London from time t) time as occasion requires. To this body belongs the duty of proposing a president, of preparing for the approval of the general committee the list of vice-presidents and sectional officers, the selection of evening lecturers, and other arrangements for the coming meeting. At the present time another class of questions occupies a good deal of the attention of the council. In the first generation of the association, and during the period of unwritten, but not yet traditional, law, questions relating to our own organization or procedure either "settled themselves," or were wisely left to the discretionary powers of those who had taken part in our proceedings during the early years of our existence. These and other kindred subjects now require more careful formularization and more deliberate sanction. And it is on the shoulders of the council that the weight of these matters in general falls. These facts deserve especial mention on the present occasion, because one part of our business at the close of this meeting will be to bid farewell officially to one who has served us as assistant secretary so long and so assiduously that he has latterly become our main repertory of information and our mentor upon questions of precedence and procedure. The post hitherto held by Mr. Griffith (for it is to him I allude) will doubtless be well filled by the able and energetic member who has been nominated in his place; but I doubt not that even he will be glad for some time to come to draw largely upon the

knowledge and experience of his predecessor.

But, beside matters of internal arrangement and organization, the duties of the council comprise a variety of scientific subjects referred to them by the general committee, at the instance of the committee of recommendations, for deliberation and occasionally for action. With the increasing activity of our body in general, and more particularly with that of our various officers, these duties have of late years become more varied and onerous than formerly; nor is it to be wished that they should diminish in either variety or extent. Once more, questions beyond our own constitution, and even beyond the scope of our own immediate action, such as education, legislation affecting either the promotion or the applications of science to industrial and social life, which have suggested themselves at our meetings, and received the preliminary sanction of our committee of recommendations, are frequently referred to our council. These, and others which it is unnecessary to particularize, whether discussed in full council or in committees specially appointed by that body, render the duties of our councillors as onerous as they are important.

While the Government has at all times, but in a more marked manner of late years, recognized the Royal Society of London, with representatives from the sister societies of Dublin and of Edinburgh, as the body to which it should look for counsel and advice upon scientific questions, it has *still never* shown itself indisposed to receive and entertain any well-considered recommendation from the British Association. Two special causes have in all probability contributed largely to this result. First, the variety of elements comprised by the association, on account of which its recommendations imply a more general concurrence of scientific opinion than those of any other scientific body; secondly, the peculiar fact that our period of *maximum* activity coincides with that of *minimum* activity of other scientific bodies is often of the highest importance. At the very time when the other bodies are least able we are most able to give deliberate consideration and formal sanction to recommendations, whether in the form of applications to Government or otherwise, which may arise. In many of these time is an element so essential that it is not too much to say that, without the intervention of the British Association, many opportunities for the advancement of science, especially at the seasons in question, might have been lost. The Government has, moreover, formally recognized our scientific existence by appointing our president for the time being a member of the Government Fund Committee; and the public has added its testimony to our importance and utility by imposing upon our president and officers a variety of duties, among which are conspicuous those which arise out of its very liberal exercise of civic and other hospitality.

Of the nature and functions of the presidential address this is, perhaps, neither the time nor the place to speak; but, if I might

for a moment forget the purpose for which we are now assembled, I would take the opportunity of reminding those who have not attended many of our former meetings that our annual volumes contain a long series of addresses on the progress of science from a number of our most eminent men, to which there is, perhaps, no parallel elsewhere. These addresses are, perhaps, as remarkable for their variety in mode of treatment as for the value of their subject-matter. Some of our presidents, and especially those who officiated in the earlier days of our existence, have passed in review the various branches of science, and have noted the progress made in each during the current year. But, as the various sciences have demanded more and more special treatment on the part of those who seriously pursue them, so have the cases of individuals who can of their own knowledge give anything approaching to a general review become more and more rare. To this may be added the fact that although no year is so barren as to fail in affording sufficient crop for a strictly scientific budget, or for a detailed report of progress in research, yet one year is more fertile than another in growths of sufficient prominence to arrest the attention of the general public and to supply topics suitable for the address. On these accounts apparently such a presidential survey has ceased to be annual, and has dropped into an intermittence of longer period. Some presidents have made a scientific principle, such as the time-element in natural phenomena, or continuity, or natural selection, the theme of their discourse, and have gathered illustrations from various branches of knowledge. Others, again, taking their own special subject as a fundamental note, and thence modulating into other kindred keys, have borne testimony to the fact that no subject is so special as to be devoid of bearing or of influence on many others. Some have described the successive stages of even a single but important investigation; and while tracing the growth of that particular item and of the ideas involved in it, have incidentally shown to the outer world what manner of business a serious investigation is. But there is happily no pattern or precedent which the president is bound to follow; both in range of subject matter and in mode of treatment each has exercised his undoubted right of taking an independent line. And it can hardly be doubted that a judicious exercise of this freedom has contributed more than anything else to sustain the interest of a series of annual discourses extending now over nearly half a century.

The nature of the subjects which may fairly come within the scope of such a discourse has of late been much discussed, and the question is one upon which everyone, of course, is entitled to form his own judgment; but lest there should be any misapprehension as to how far it concerns us in our corporate capacity, it will be well to remind my hearers that as, on the one hand, there is no discussion on the presidential address, and the members as a body express no formal opinion upon it, so, on the other, the association

cannot fairly be considered as in any way committed to its tenor or conclusions. Whether this immunity from comment and reply be really on the whole so advantageous to the president as might be supposed need not here be discussed; but suffice it to say that the case of an audience assembled to listen without discussion finds a parallel elsewhere, and in the parallel case it is not generally considered that the result is altogether either advantageous to the speaker or conducive to excellence in the discourse. But, apart from this, the question of a limitation of range in the subject matter for the presidential address is not quite so simple as may at first sight appear. It must, in fact, be borne in mind, while on the one hand knowledge is distinct from opinion, from feeling, and from all other modes of subjective impression, still the limits of knowledge are at all times expanding, and the boundaries of the known and the unknown are never rigid or permanently fixed. That which in time past or present has belonged to one category may in time future belong to the other. Our ignorance consists partly in ignorance of actual fact, and partly also in ignorance of the possible range of ascertainable fact.

If we could lay down beforehand the precise limits of possible knowledge, the problem of physical science would be already half solved. But the question to which the scientific explorer has often to address himself is not merely whether he is able to solve this or that problem, but whether he can so far unravel the tangled threads of the matter with which he has had to deal as to weave them into a definite problem at all. He is not like a candidate at an examination with a precise set of questions placed before him; he must first himself act the part of the examiner and select questions from the repertory of nature, and upon them found others, which in some sense are capable of definite solution. If his eye seem dim, he must look steadfastly and with hope into the misty vision, until the very clouds wreathe themselves into definite forms. If his ear seem dull, he must listen patiently and with sympathetic trust to the intricate whisperings of nature—the goddess, as she has been called, of a hundred voices—until here and there he can pick out a few simple notes to which his own powers can resound. If, then, at a moment when he finds himself placed on a pinnacle from which he is called upon to take a perspective survey of the range of science, and to tell us what he can see from his vantage ground; if, at such a moment, after straining his gaze to the very verge of the horizon, and after describing the most distant of well-defined objects, he should give utterance also to some of the subjective impressions which he is conscious of receiving from regions beyond; if he should depict possibilities which seem opening to his view; if he should explain why he thinks this a mere blind alley and that an open path; then the fault and the loss would be alike ours if we refused to listen calmly, and temperately to form our own judgment on what we hear; then assuredly it is we who

would be committing the error of confounding matters of fact and matters of opinion, if we failed to discriminate between the various elements contained in such discourse, and assumed that they had all been put on the same footing. But to whatever decision we may each come on these controverted points, one thing appears clear from a retrospect of past experience—viz., that first or last, either at the outset, in his choice of subject or in the conclusions ultimately drawn therefrom, the president, according to his own account at least, finds himself on every occasion in a position of "exceptional or more than usual difficulty." And your present representative, like his predecessors, feels himself this moment in a similar predicament. The reason which he now offers is that the branch of science which he represents is one whose lines of advance, viewed from a mathematician's own point of view, offer so few points of contact with the ordinary experiences of life or modes of thought, that any account of its actual progress which he might have attempted must have failed in the first requisite of an address—namely, that of being intelligible.

Now if this esoteric view had been the only aspect of the subject which he could present to his hearers, he might well have given up the attempt in despair. But although in its technical character mathematical science suffers the inconveniences, while it enjoys the dignity, of its Olympian position, still in a less formal garb, or in *disguise, if you* are pleased so to *call it, it is found* present at many an unexpected turn; and although some of us may never have learnt its special language, not a few have, all through our scientific life, and even in almost every accurate utterance, like Molière's well-known character, been talking mathematics without knowing it. It is, moreover, a fact not to be overlooked that the appearance of isolation, so conspicuous in mathematics, appertains in a greater or less degree to all other sciences, and perhaps also to all pursuits in life. In its highest flight each soars to a distance from its fellows. Each is pursued alone for its own sake, and without reference to its connection with, or its application to, any other subject. The pioneer and the advanced guard are of necessity separated from the main body, and in this respect mathematics does not materially differ from its neighbours. And, therefore, as the solitariness of mathematics has been a frequent theme of discourse, it may be not altogether unprofitable to dwell for a short time upon the other side of the question, and to inquire whether there be not points of contact in method or in subject-matter between mathematics and the outer world which have been frequently overlooked; whether its lines do not in some cases run parallel to those of other occupations and purposes of life; and, lastly, whether we may not hope for some change in the attitude too often assumed towards it by the representatives of other branches of knowledge and of mental activity.

In his preface to the "Principia," Newton gives expression

to some general ideas which may well serve as the key-note for all future utterances on the relation of mathematics to natural, including also therein what are commonly called artificial, phenomena :—

"The ancients divided mechanics into two parts—rational and practical; and since artisans often work inaccurately, it came to pass that mechanics and geometry were distinguished in this way—that everything accurate was referred to geometry, and everything inaccurate to mechanics. But the inaccuracies appertain to the artisan and not to the art, and geometry itself has its foundation in mechanical practice, and is, in fact, nothing else than that part of universal mechanics which accurately lays down and demonstrates the art of measuring."[2] He next explains that rational mechanics is the science of motion resulting from forces, and adds: "The whole difficulty of philosophy seems to me to lie in investigating the forces of nature from the phenomena of motion, and in demonstrating that from these forces other phenomena will ensue." Then, after stating the problems of which he has treated in the work itself, he says: "I would that all other natural phenomena might similarly be deduced from mechanical principles. For many things move me to suspect that everything depends upon certain forces in virtue of which the particles of bodies, through forces not yet understood, are either impelled together so as to cohere in regular figures, or are repelled and recede from one another."

Newton's views, then, are clear. He regards mathematics not as a method independent of, though applicable to, various subjects, but as itself the higher side or aspect of the subjects themselves; and it would be little more than a translation of his notions into other language, little more than a paraphrase of his own words, if we were to describe the mathematical as one aspect of the material world itself, apart from which all other aspects are but incomplete sketches, and, however accurate after their own kind, are still liable to the imperfections of the inaccurate artificer. Mr. Burrowes, in his preface to the first volume of the "Transactions of the Royal Irish Academy," has carried out the same argument, approaching it from the other side. "No one science," he says, "is so little connected with the rest as not to afford many principles whose use may extend considerably beyond the science to which they primarily belong, and no proposition is so purely theoretical as to be incapable of being applied to practical purposes. There is no apparent connexion between duration and the cycloidal arch, the properties of which have furnished us with the best method of measuring time; and he who has made himself master of the nature and affections of the logarithmic curve, has advanced considerably towards ascertaining the proportionable density of the air at various distances from the earth. The researches of the

[2] Compare with this the latter part of Plato's "Philebus," on knowledge and the handicraft arts; also Professor Jowett's "Introduction" thereto.

mathematician are the only sure ground on which we can reason from experiments; and how far experimental science may assist commercial interests is evinced by the success of manufactures in countries where the hand of the artificer has taken its direction from the philosopher. Every manufacture is in reality but a chemical process, and the machinery requisite for carrying it on but the right application of certain propositions in rational mechanics." So far your academician. Every subject, therefore, whether in its usual acceptation, scientific or otherwise, may have a mathematical aspect; as soon, in fact, as it becomes a matter of strict measurement, or of numerical statement, so soon does it enter upon a mathematical phase. This phase may, or it may not, be a prelude to another in which the laws of the subject are expressed in algebraical formulæ or represented by geometrical figures. But the real gist of the business does not always lie in the mode of expression, and the fascination of the formulæ or other mathematical paraphernalia may after all be little more than that of a theatrical transformation scene. The process of reducing to formulæ is really one of abstraction, the results of which are not always wholly on the side of gain; in fact, through the process itself, the subject may lose in one respect even more than it gains in another. But long before such abstraction is completely attained, and even in cases where it is never attained at all, a subject may to all intents and purposes become mathematical. It is not so much elaborate calculations or abstruse processes which characterise this phase as the principles of precision, of exactness, and of proportion. But these are principles with which no true knowledge can entirely dispense. If it be the general scientific spirit which at the outset moves upon the face of the waters, and out of the unknown depth brings forth light and living forms, it is no less the mathematical spirit which breathes the breath of life into what would otherwise have ever remained mere dry bones of fact, which reunites the scattered limbs and recreates from them a new and organic whole.

And, as a matter of fact, in the words used by Professor Jellett at our meeting in Belfast—viz., "Not only are we applying our methods to many sciences already recognized as belonging to the legitimate province of mathematics, but we are learning to apply the same instrument to sciences hitherto wholly or partially independent of its authority. Physical science is learning more and more every day to see in the phenomena of nature modifications of that one phenomenon—namely, motion—which is peculiarly under the power of mathematics." Echoes are these, far off and faint perhaps, but still true echoes, in answer to Newton's wish that all these phenomena may some day "be deduced from mechanical principles."

If, turning from this aspect of the subject, it were my purpose to enumerate how the same tendency has evinced itself in the arts, unconsciously it may be to the artists themselves, I might call as wit-

nesses each one in turn, with full reliance on the testimony which they would bear. And, having more special reference to mathematics, I might confidently point to the accuracy of measurement, to the truth of curve, which, according to modern investigation, is the key to the perfection of classic art. I might triumphantly cite not only the architects of all ages, whose art so manifestly rests upon mathematical principles, but I might cite also the literary as well as the artistic remains of the great artists of Cinque-cento, both painters and sculptors, in evidence of tho geometry and the mechanics which having been laid at the foundation, appear to have found their way upwards through the superstructure of their works.[3] And in a less ambitious sphere, but nearer to ourselves in both time and place, I might point with satisfaction to the great school of English constructors of the 18th century in the domestic arts, and remind you that not only the engineer and the architect, but even the cabinet-makers devoted half the space of their books to perspective and to the principles whereby solid figures may be delineated on paper, or what is now termed descriptive geometry.[4]

Nor, perhaps, would the sciences which concern themselves with reasoning and speech, nor the kindred art of music, nor even literature itself, if thoroughly probed, offer fewer points of dependence upon the science of which I am speaking. What, in fact, is logic but that part of universal reasoning; grammar but that part of universal speech; harmony and counterpoint but that part of universal music, "which accurately lays down" and demonstrates (so far as demonstration is possible) precise methods appertaining to each of these arts? And I might even appeal to the common consent which speaks of the mathematical as the pattern form of reasoning and model of a precise style.

Taking, then, precision and exactness as the characteristics which distinguish the mathematical phase of a subject, we are naturally led to expect that the approach to such a phase will be indicated by increasing application of the principle of measurement, and by the importance which is attached to numerical results. And this very necessary condition for progress may, I think, be fairly described as one of the main features of scientific advance of the present day.

If it were my purpose, by descending into the arena of special sciences, to show how the most various investigations alike tend to issue in measurement, and to that extent to assume a mathematical phase, I should be embarrassed by the abundance of instances which might be adduced. I will therefore confine myself to a passing notice of a very few, selecting those which exemplify not only the general tendency, but also the special character of

[3] See "Trattato della Pittura," by Leonardo da Vinci; also the "Memoir on the MSS. of L. d. V.," by Venturi, 1797.

[4] "The Gentleman and Cabinet Maker's Director," by Thomas Chippendale, London, 1754. "The Cabinet Maker and Upholsterer's Drawing Book," by *Thomas Sheraton*, London, 1793.

the measurements now particularly required—viz., that of minuteness, and the indirect method by which alone we can at present hope to approach them. An object having a diameter of an 80,000th of an inch is, perhaps, the smallest of which the microscope could give any well-defined representation; and it is improbable that one of 120,000th of an inch could be singly discerned with the highest powers at our command. But the solar beams and the electric light reveal to us the presence of bodies far smaller than these.[5] And, in the absence of any means of observing them singly, Professor Tyndall has suggested a scale of these minute objects in terms of the lengths of luminiferous waves. To this he was led, not by any attempt at individual measurement, but by taking account of them in the aggregate, and observing the tints which they scatter laterally when clustered in the form of actinic clouds.[6] These small bodies, with which experimental science has recently come into contact, are not confined to gaseous molecules, but comprise also complete organisms; and the same philosopher has made a profound study of the momentous influence exerted by these minute organisms in the economy of life.[7] And if, in view of their specific effects, whether deleterious or otherwise on human life, any qualitative classification or quantitative estimate be ever possible, it seems that it must be effected by some such method as that indicated above.

Again, to enumerate a few more instances of the measurement of minute quantities, there are the average distances of molecules from one another in various gases and at various pressures, the length of their free path or range open for their motion without coming into collision; there are movements causing the pressures and difference of pressure under which Mr. Crookes's radiometers execute their wonderful revolutions;[8] there are the excursions of the air while transmitting notes of high pitch, which through the researches of Lord Rayleigh appear to be of a diminutiveness altogether unexpected;[9] there are the molecular actions brought into play in the remarkable experiments by Dr. Kerr,[10] who has succeeded, where even Faraday failed, in effecting a visible rotation of the plane of polarization of light in its passage through electrified dielectrics and on its reflection at the surface of the magnet. To take one more instance, which must be present to the minds of us all, there are the infinitesimal ripples of the vibrating plate in Mr. Graham Bell's most marvellous invention. Of the nodes and ventral segments in the plate of the telephone, which actually converts sound into electricity and electricity into sound, we can at present form no conception. All that can now be said is that the most perfect specimens of Chladni's sand figures on a vibra-

5 See Sorby's Address to the Microscopical Society, 1876.
6 "Phil. Trans. of the Royal Society," 1870, p. 333; and 1876, p. 27.
7 "Phil. Transactions," 1877, p. 149.

8 "On Attraction and Repulsion resulting from Radiation," "Phil. Trans.," 1874, p. 501; 1875, p. 519; 1876, p. 325.
9 "Philosophical Magazine," April, 1878.
10 "Philosophical Magazine," 1875, pp. 337, 446; 1877, Vol. i., p. 321; 1878, Vol. i., p. 161.

ting plate, or of Kundt's lycopodium heaps in a musical tube, or even Mr. Sedley Taylor's more delicate vortices in the films of the phoneidoscope, are rough and sketchy compared with these.[11] For notwithstanding the fact that in the movements of the telephone plate we have actually in our hand the solution of that old world problem, the construction of a speaking machine, yet the characters in which that solution is expressed are too small for our powers of decipherment. In movements such as these we seem to lose sight of the distinction, or, perhaps, we have unconsciously passed the boundary between massive and molecular motion.

Through the phonograph we have not only a transformation, but a permanent and tangible record of the mechanism of speech. But the differences upon which articulation, apart from loudness, pitch, and quality, depends appear from the experiments of Fleeming Jenkin and of others to be of microscopic size. The microphone affords another instance of the unexpected value of minute variations—in this case of electric currents; and it is remarkable that the gist of the instrument seems to lie in obtaining and performing that which electricians have hitherto most scrupulously avoided—viz., loose contact.[12]

Once more, Mr. De La Rue has brought forward, as one of the results derived from his stupendous battery of 10,000 cells, strong evidence for supposing that a voltaic discharge, even when apparently continuous, may still be an intermittent phenomenon; but all that is known of the period of such intermittence is that it must recur at exceedingly short intervals. And in connexion with this subject, it may be added that whatever be the ultimate explanation of the strange stratification which the voltaic discharge undergoes in rarefied gases, it is clear that the alternate disposition of light and darkness must be dependent on some periodic distribution in space or sequence in time which can at present be dealt with only in a very general way. In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure. It may also be added that some of the features accompanying stratification form a magnified image of phenomena belonging to disruptive discharges in general; and that, consequently, so far from expecting among the known facts of the latter any clue to an explanation of the former, we must hope ultimately to find in the former an elucidation of what is at present obscure in the latter. A prudent philosopher usually avoids hazarding any forecast of the practical application of a purely scientific research. But it would seem that the configuration of these striæ might some day prove a very delicate means of estimating low

[11] Poggendorff's "Annalen," Tom. xxxv, p. 337. "Royal Society's Proceedings," 1878.

[12] "Phil. Trans.," Vol. 169, pp. 55 and 155, and other papers catalogued in the "*Appendix to Part II. of the Memoir.*"

pressures, and perhaps also for effecting some electrical measurements.

Now, it is a curious fact that almost the only small quantities of which we have as yet any actual measurements are the wave-lengths of light; and that all others, excepting so far as they can be deduced from these, await further determination. In the meantime, when unable to approach these small quantities individually, the method to which we are obliged to have recourse is, as indicated above, that of averages, whereby, disregarding the circumstances of each particular case, we calculate the average size, the average velocity, the average direction, &c., of a large number of instances.[13] But although this method is based upon experience and leads to results which may be accepted as substantially true; although it may be applicable to any finite interval of time or over any finite area of space—that is, for all practical purposes of life—there is no evidence to show that it is so when the dimension of interval or of area are indefinitely diminished. The truth is that the simplicity of nature which we at present grasp is really the result of infinite complexity; and that below the uniformity there underlies a diversity the depths of which we have not yet probed, and the secret places of which are still beyond our reach.

The present is not an occasion for multiplying illustrations, but I can hardly omit a passing allusion to one all-important instance of the application of the statistical method. Without its aid, social life, or the history of life and death, could not be conceived at all, or only in the most superficial manner. Without it, we could never attain to any clear ideas of the condition of the poor, we could never hope for any solid amelioration of their condition or prospects. Without its aid, sanitary measures, and even medicine, would be powerless. Without it, the politician and the philanthropist would alike be wandering over a trackless desert.

It is, however, not so much from the side of science at large as from that of mathematics itself that I desire to speak. I wish from the latter point of view to indicate connexions between mathematics and other subjects, to prove that here is not, after all, such a far-off region, nor so undecipherable an alphabet, and to show that even at unlikely spots we may trace under-currents of thought which having issued from a common source fertilize alike the mathematical and non-mathematical world.

Having this in view, I propose to make the subject of special remark some processes peculiar to modern mathematics; and partly with the object of incidentally removing some current misapprehensions, I have selected for examination three methods, in respect of which mathematicians are often thought to have exceeded all reasonable limits of speculation, and to have adopted for unknown purposes an unknown tongue. And it will be my endeavour to show not only that in these very cases our science has not outstepped its own legitimate

13 See Maxwell "On Heat," chap. xxii.

range, but that even art and literature have unconsciously employed methods similar in principle. The three methods in question are—first, that of imaginary quantities; secondly, that of manifold space; and thirdly, that of geometry not according to Euclid.

First, it is objected that, abandoning the more cautious methods of ancient mathematicians, we have admitted into our formulæ quantities which by our own showing, and even in our own nomenclature, are imaginary or impossible; nay, more, that out of them we have formed a variety of new algebras to which there is no counterpart whatever in reality; but from which we claim to arrive at possible and certain results. On this head it is in Dublin, if anywhere, that I may be permitted to speak. For to the fertile imagination of the late Astronomer Royal for Ireland we are indebted for that marvellous calculus of quaternion, which is only now beginning to be fully understood, and which has not yet received all the applications of which it is doubtless capable. And even although this calculus be not co-extensive with another which almost simultaneously germinated on the Continent,[14] nor with ideas more recently developed in America,[15] yet it must always hold its position as an original discovery and as a representative of one of the two great groups of generalised algebras (viz., those the squares of whose units are respectively negative unity and zero), the common origin of which must still be marked on our intellectual map as an unknown region. Well do I recollect how in its early days we used to handle the method as a magician's page might try to wield his master's wand, trembling as it were between hope and fear, and hardly knowing whether to trust our own results until they had been submitted to the present and ever ready counsel of Sir W. R. Hamilton himself.

To fix our ideas, consider the measurement of a line, or the reckoning of time, or the performance of any mathematical operation. A line may be measured in one direction or in the opposite; time may be reckoned forward or backward; an operation may be performed or be reversed, it may be done or may be undone; and if having once reversed any of these processes we reverse it a second time, we shall find that we have come back to the original direction of measurement or of reckoning, or to the original kind of operation.

Suppose, however, that at some stage of a calculation our formulæ indicate an alteration in the mode of measurement such that, if the alteration be repeated, a condition of things not the same as, but the reverse of the original, will be produced. Or suppose that, at a certain stage, our transformations indicate that time is to be reckoned in some manner different from future or past, but still in a way having definite algebraical connection with time which is gone and time which is to come. It is clear that in actual experience there is no process to which such measurements correspond.[16] Time

[14] Grunert's "Archiv.," Vol, vi., p. 337; also separate work, Berlin, 1862.

[15] "Linear Associative Algebra," by *Benjamin Peirce*, Washington City, 1870.

[16] Sir Wm. Thompson, "Cambridge

has no meaning except as future or past, and the present is but the meeting point of the two. Or, once more, suppose that we are gravely told that all circles pass through the same two imaginary points at an infinite distance, and that every line drawn through one of these points is perpendicular to itself. On hearing the statement, we shall probably whisper, with a smile or a sigh, that we hope it is not true; but that in any case it is a long way off, and perhaps, after all, it does not very much signify. If, however, as mathematicians we are not satisfied to dismiss the question on these terms, we ourselves must admit that we have here reached a definite point of issue. Our science must either give a rational account of the dilemma or yield the position as no longer tenable.

Special modes of explaining this anomalous state of things have occurred to mathematicians. But, omitting details as unsuited to the present occasion, it will, I think, be sufficient to point out in general terms that a solution of the difficulty is to be found in the fact that the formulæ which give rise to these results are more comprehensive than the signification assigned to them, and when we pass out of the condition of things first contemplated they cannot (as it is obvious they ought not) give us any results intelligible on that basis. But it does not, therefore, by any means follow that upon a more enlarged basis the formulæ are incapable of interpretation; on the contrary, the difficulty at which we arrived indicates that there must be some more comprehensive statement of the problem which will include cases impossible in the more limited, but possible in the wider view of the subject.

A very simple instance will illustrate the matter. If from a point outside a circle we draw a straight line to touch the curve, the distance between the starting point and the point of contact has certain geometrical properties. If the starting point be shifted nearer and nearer to the circle, the distance in question becomes shorter and ultimately vanishes. But as soon as the point passes to the interior of the circle the notion of a tangent and distance to the point of contact cease to have any meaning; and the same anomalous condition of things prevails as long as the point remains in the interior. But if the point be shifted still further until it emerges on the other side, the tangent and its properties resume their reality, and are as intelligible as before. Now the process whereby we have passed from the possible to the impossible and again repassed to the [illegible]

Mathematical Journal," Vol. iii., p. 174. Jevon's "Principles of Science," Vol. ii., p. 438.

"But an explanation of the difficulty seems to me to be found in the fact that the problem, as stated, is one of the conduction of heat, and that the 'impossibility' which attaches itself to the expression for the 'time' merely means that previous to a certain epoch the conditions which gave rise to the phenomena were not those of conduction, but those of some other action of heat. If, therefore, we desire to comprise the phenomena of the earlier as well as of the latter period in one problem we must find some more general statement—viz., that of physical conditions which at the critical epoch will issue in a case of conduction. I think that Professor Clifford has somewhere given a similar explanation."

(namely, the shifting of the starting point) is a perfectly continuous one, while the conditions of the problem as stated above have been abruptly changed.

If, however, we replace the idea of a line touching by that of a line cutting the circle, and the distance of the point of contact by the distances at which the line is intercepted by the curve, it will easily be seen that the latter includes the former as a limiting case, when the cutting line is turned about the starting point until it coincides with the tangent itself; and further, that the two intercepts have a perfectly distinct and intelligible meaning whether the point be outside or inside the area. The only difference is that in the first case the intercepts are measured in the same direction; in the latter in opposite directions.

The foregoing instance has shown one purpose which these imaginaries may serve—viz., as marks indicating a limit to a particular condition of things, to the application of a particular law, or pointing out a stage where a more comprehensive law is required. To attain to such a law we must, as in the instance of the circle and tangent, reconsider our statement of the problem; we must go back to the principle from which we set out, and ascertain whether it may not be modified or enlarged. And even, if in any particular investigation wherein imaginaries have occurred, the most comprehensive statement of the problem of which we are at present capable fails to give an actual representation of these quantities; if they must for the present be relegated to the category of imaginaries, it still does not follow that we may not at some future time find a law which will endow them with reality, nor that in the meantime we need hesitate to employ them, in accordance with the great principle of continuity, for bringing out correct results.

If, moreover, both in geometry and in algebra we occasionally make use of points or of quantities which, from our present outlook have no real existence, which can neither be delineated in space of which we have experience, nor measured by scale as we count measurement; if these imaginaries, as they are termed, are called up by legitimate processes of our science; if they serve the purpose, not merely of suggesting ideas, but of actually conducting us to practical conclusions; if all this be true in abstract science, I may perhaps be allowed to point out, in illustration of my argument, that in art unreal forms are frequently used for suggesting ideas, for conveying a meaning for which no others seem to be suitable or adequate. Are not forms unknown to biology, situations incompatible with gravitation, positions which challenge not merely the stability but even the possibility of equilibrium—are not these the very means to which the artist often has recourse in order to convey his meaning and to fulfil his mission? Who that has ever revelled in the ornamentation of the Renaissance, in the extraordinary transitions from the animal to the vegetable, from faunic to floral forms, and from those again to almost purely

geometric curves—who has not felt that those imaginaries have a claim to recognition very similar to that of their congeners in mathematics? How is it that the grotesque paintings of the Middle Ages, the fantastic sculpture of remote nations, and even the rude art of the prehistoric past, still impress us, and have an interest over and above their antiquarian value, unless it be that they are symbols which, although hard of interpretation when taken alone, are yet capable, from a more comprehensive point of view, of leading us mentally to something beyond themselves, and to truths which, although reached through them, have a reality scarcely to be attributed to their outward forms?

Again, if we turn from art to letters, truth to nature and to fact is undoubtedly a characteristic of sterling literature; and yet in the delineation of outward nature itself, still more in that of feelings and affections, of the secret parts of character and motives of conduct, it frequently happens that the writer is driven to imagery, to an analogy, or even to a paradox, in order to give utterance to that of which there is no direct counterpart in recognized speech. And yet which of us cannot find a meaning for these literary figures, an inward response to imaginative poetry, to social fiction, or even to those tales of giant and fairyland written, it is supposed, only for the nursery or schoolroom? But in order thus to reanimate these things with a meaning beyond that of the mere words, have we not to reconsider our first position, to enlarge the ideas with which we started; have we not to cast about for something which is common to the idea conveyed and to the subject actually described, and to seek for the sympathetic spring which underlies both; have we not, like the mathematician, to go back, as it were, to some first principles, or, as it is pleasanter to describe it, to become again as a little child.

Passing again to the second of the three methods—viz., that of manifold space, it may first be remarked that our whole experience of space is in three dimensions, viz., of that which has length, breadth, and thickness; and if for certain purposes we restrict our ideas to two dimensions as in plane geometry, or to one dimension as in the division of a straight line, we do this only by consciously and of deliberate purpose setting aside, but not annihilating, the remaining one or two dimensions. Negation, as Hegel has justly remarked, implies that which is negatived, or, as he expresses it, affirms the opposite. It is by abstraction from previous experience, by a limitation of its results, and not by any independent process, that we arrive at the idea of space whose dimensions are less than three.

It is doubtless on this account that problems in plane geometry, although capable of solution on their own account, become much more intelligible, more easy of extension, if viewed in connection with solid space, and as special cases of corresponding problems in solid geometry. So eminently is this the case that the very language of the more general method often leads us almost intuitively

to conclusions which, from the more restricted point of view, require long and laborious proof. Such a change in the base of operation has, in fact, been successfully made in geometry of two dimensions, and although we have not the same experimental data for the future steps, yet neither the modes of reasoning nor the validity of its conclusions are in any way affected by applying an analogous mental process to geometry of three dimensions; and by regarding figures in spaces of three dimensions as sections of figures in space of four, in the same way that figures in plane are sometimes considered as sections of figures in solid space. The addition of a fourth dimension to space not only extends the actual properties of geometrical figures, but it also adds new properties which are often useful for the purposes of transformation or of proof. Thus it has recently been shown that in four dimensions a closed material shell could be turned inside out by simple flexure, without either stretching or tearing; [17] and that in such a space it is impossible to tie a knot. [18]

Again, the solution of problems in geometry is often effected by means of algebra; and as three measurements, or co-ordinates as they are called, determine the position of a point in space, so do three letters or measurable quantities serve for the same purpose in the language of algebra. Now, many algebraical problems involving three unknown or variable quantities admit of being generalized so as to give problems involving many such quantities. And as, on the one hand, to every algebraical problem involving unknown quantities or variables by ones or by twos, or by threes, there corresponds a problem in geometry of one or of two or of three dimensions, so on the other it may be said that to every algebraical problem involving many variables there corresponds a problem in geometry of many dimensions.

There is, however, another aspect under which even ordinary space presents to us a fourfold, or indeed a manifold, character. In modern physics, space is regarded not as a vacuum, in which bodies are placed and forces have play, but rather as a plenum, with which matter is co-extensive. And, from a physical point of view, the properties of space are the properties of matter or of the medium which fills it. Similarly, from a mathematical point of view, space may be regarded as a *locus in quo*, as a plenum filled with those elements of geometrical magnitude which we take as fundamental. These elements need not always be the same. For different purposes different elements may be chosen, and upon the degree of complexity of the subject of our choice will depend the internal structure or manifoldness of space.

Thus, beginning with the simplest case, a point may have any singly infinite multitude of positions in a line, which gives a onefold system of points in a line.

[17] S. Newcomb "On Certain Transformations of Surfaces," "American Journal of Mathematics," Vol i., p. 1.

[18] Tait "On Knots," "Transactions of the Royal Society of Edinburgh," Vol. xxviii., p. 145; Klein, "Mathematische *Annalen*," ix., p. 478.

The line may revolve in a plane about anyone of its points, giving a twofold system of points in plane; and the plane may revolve about any one of the lines, giving a threefold system of points in space.

Suppose, however, that we take a straight line as our element, and conceive space as filled with such lines. This will be the case if we take two planes—*e.g.*, two parallel planes, and join every point in one with every point in the other. Now, the points in a plane form a twofold system, and it therefore follows that the system of lines is fourfold; in other words, space regarded as a plenum of lines is fourfold. The same result follows from the consideration that the lines in a plane, and the planes through a point, are each twofold.

Again, if we take a sphere as our element we can through any point as a centre draw a singly infinite number of spheres, but the number of such centres is triply infinite; hence space as a plenum of spheres is fourfold. And generally space as a plenum of surfaces has a manifoldness equal to the number of constants required to determine the surface. Although it would be beyond our present purpose to attempt to pursue the subject further, it should not pass unnoticed that the identity in the fourfold character of space, as derived on the one hand from a system of straight lines, and on the other from a system of spheres, is intimately connected with the principles established by Sophus Lie in his researches on the correlation of these figures.

If we take a circle as our element, we can around any plane as a centre draw a singly infinite system of circles: but the number of such centres in a plane is doubly infinite: hence the circles in a plane form a threefold system, and as the planes in space form a threefold system, it follows that space as a plenum of circles is sixfold.

Again, if we take a circle as our element, we may regard it as a section either of a sphere or of a right cone given (except in position) by a plane perpendicular to the axis. In the former case the position of the centre is threefold; the directions of the plane, like that of a pencil of lines perpendicular thereto, twofold; and the radius of the sphere onefold; sixfold in all. In the latter case, the position of the vertex is threefold; the direction of the axis twofold; and the distance of the plane of section onefold: sixfold in all, as before. Hence space as a plenum of circles if sixfold.

Similarly, if we take a conic as our element we regard it as a section of a right cone given (except in position) by a plane. If the nature of the conic be defined, the plane of section will be inclined at a fixed angle to the axis, otherwise it will be free to take any inclination whatever. This being so, the position or the vertex will be threefold, the direction of the axis twofold, the distance of the plane of section from the vertex onefold, and the direction of that plane onefold if the conic be defined, twofold if it be not defined. Hence, space as a plenum of definite conics will be sevenfold, as a plenum of conics in general eightfold, and so for curves of higher degrees.

This is, in fact, the whole story and mystery of manifold space. It is not seriously regarded as a reality in the same sense as ordinary space; it is a mode of representation, or a method which, having served its purpose, vanishes from the scene. Like a rainbow, if we try to grasp it, it eludes our very touch; but, like a rainbow, it arises out of real conditions of known and tangible quantities, and if rightly apprehended it is a true and valuable expression of natural laws, and serves a definite purpose in the science of which it forms part.

Again, if we seek a counterpart of this in common life, I might remind you that perspective in drawing is itself a method not altogether dissimilar to that of which I have been speaking; and that the third dimension of space, as represented in a picture, has its origin in the painter's mind, and is due to his skill, but has no real existence upon the canvas which is the groundwork of his art. Or again, turning to literature, when in legendary tales, or in works of fiction, things past and future are pictured as present, has not the poetic fancy correlated time with the three dimensions of space, and brought all alike to a common focus? Or, once more, when space already filled with material substances is mentally peopled with immaterial beings, may not the imagination be regarded as having added a new element to the capacity of space, a fourth dimension of which there is no evidence in experimental fact?

The third method proposed for special remark is that which has been termed non-Euclidean geometry; and the train of reasoning which has led to it may be described in general terms as follows:—Some of the properties of space which on account of their simplicity, theoretical as well as practical, have, in constructing the ordinary system of geometry, been considered as fundamental, are now seen to be particular cases of more general properties. Thus a plane surface and a straight line may be regarded as special instances of surfaces and lines whose curvature is everywhere uniform or constant. And it is perhaps not difficult to see that, when the special notions of flatness and straightness are abandoned, many properties of geometrical figures, which we are in the habit of regarding as fundamental, will undergo profound modification. Thus a plane may be considered as a special case of the sphere—viz., the limit to which a sphere approaches when its radius is increased without limit. But even this consideration trenches upon an elementary proposition relating to one of the simplest of geometrical figures. In plane triangles the interior angles are together equal to two right angles; but in triangles traced on the surface of a sphere this proposition does not hold good. To this other instances might be added.

Further, these modifications may affect not only our ideas of particular geometrical figures, but the very axioms of the science itself. Thus, the idea, which in fact lies at the foundation of Euclid's method—viz., that a geometrical figure may be moved in space without change of size or

alteration of form, entirely falls away, or becomes only approximate in a space wherein dimension and form are dependent upon position. For instance, if we consider merely the case of figures traced on a flattened globe like the earth's surface, or upon an eggshell, such figures cannot be made to slide upon the surface without change of form, as is the case with figures traced upon a plane or even upon a sphere. But, further still, these generalizations are not restricted to the case of figures traced upon a surface; they may apply also to solid figures in a space whose very configuration varies from point to point. We may, for instance, imagine a space in which our rule or scale of measurement varies as it extends, or as it moves about, in one direction or another; a space, in fact, whose geometric density is not uniformly distributed. Thus we might picture to ourselves such a space as a field having a more or less complicated distribution of temperature, and our scale as a rod instantaneously susceptible of expansion or contraction under the influence of heat; or we might suppose space to be even crystalline in its geometric formation, and our scale and measuring instruments to accept the structure of the locality in which they are applied. These ideas are doubtless difficult of apprehension—at all events at the outset; but Helmholtz has pointed out a very familiar phenomenon which may be regarded as a diagram of such a kind of space. The picture formed by reflection from a plane mirror may be taken as a correct representation of ordinary space, in which, subject to the usual laws of perspective, every object appears in the same form and of the same dimensions, whatever be its position. In like manner the picture formed by reflection from a curved mirror may be regarded as the representation of a space wherein dimension and form are dependent upon position. Thus in an ordinary convex mirror objects appear smaller as they recede laterally from the centre of the picture; straight lines become curved; objects infinitely distant in front of the mirror appear at a distance only equal to the focal length behind. And by suitable modifications in the curvature of the mirror representations could similarly be obtained of space of various configurations.

The diversity in kind of these spaces is of course infinite; they vary with the mode in which we generalize our conceptions of ordinary space, but upon each as a basis it is possible to construct a consistent system of geometry, whose laws, as a matter of strict reasoning, have a validity and truth not inferior to those with which we are habitually familiar. Such systems having been actually constructed, the question has not unnaturally been asked, whether there is anything in nature or in the outer world to which they correspond; whether admitting that for our limited experience ordinary geometry amply suffices, we may understand that for powers more extensive in range or more minute in definition some more general scheme would be requisite? Thus, for example, although the one may serve for the solar system, is it legitimate

to suppose that it may fail to apply at distances reaching to the fixed stars, or to regions beyond? Or again, if our vision could discern the minute configurations of portions of space, which to our ordinary powers appear infinitesimally small, should we expect to find that all our usual geometry is but a special case, sufficient indeed for daily use, but after all only a rough approximation to a truer, although perhaps more complicated scheme? Traces of these questions are, in fact, to be found in the writings of some of our greatest and most original mathematicians. Gauss, Riemann, and Helmholtz have thrown out suggestions radiating as it were from a common centre; while Cayley, Sylvester, and Clifford, in this country, Klein, in Germany, Lobatcheffsky, in Russia, Bolyai, in Hungary, and Beltrami, in Italy, with many others, have reflected kindred ideas with all the modifications due to the chromatic dispersion of their individual minds. But to the main question the answer must be in the negative. And, to use the words of Newton, since "Geometry has its foundation in mechanical practice," the same must be the answer until our experience is different from what it now is. And yet, all this notwithstanding, generalized conceptions of space are not without their practical utility. The principle of representing space of one kind by that of another, and figures belonging to one by their analogues in the other, is not only recognized as legitimate in pure mathematics, but has long ago found its application in cartography. In maps or charts, geographical positions, the contour of coasts, and other features belonging in reality to the earth's surface, are represented on the flat; and to each mode of representation, or projection, as it is called, there corresponds a special correlation between the spheroid and the plane. To this might perhaps be added the method of descriptive geometry, and all similar processes in use by engineers, both military and civil.

It has often been asked whether modern research in the field of pure mathematics has not so completely outstripped its physical applications as to be practically useless; whether the analyst and the geometer might not now, and for a long time to come, fairly say, "hic artem remumque repono," and turn his attention to mechanics and to physics. That the pure has outstripped the applied is largely true; but that the former is on that account useless is far from true. Its utility often crops up at unexpected points; witness the aids to classification of physical quantities, furnished by ideas (of Scaler and Vector) involved in the calculus of quaternions; or the advantages which have accrued to physical astronomy from Lagrange's equations and from Hamilton's principle of varying action; or the value of complex quantities, and the properties of general integers, and of general theorems on integration for the theories of electricity and magnetism. The utility of such researches can in no sense be discounted or even imagined beforehand. Who, for instance,

would have supposed that the calculus of forms or the theory of substitutions would have thrown much light upon ordinary equations, or that Abelian functions and hyperelliptic transcendents would have told us anything about the properties of curves, or that the calculus of operations would have helped us in any way towards the figure of the earth? But upon such technical points I must not now dwell. If, however, as I hope, it has sufficiently shown that any of these more extended ideas enable us to combine together, and to deal with as one, properties and processes which from the ordinary point of view present marked distinctions, then they will have justified their own existence; and in using them we shall not have been walking in a vain shadow nor disquieting our brains in vain.

These extensions of mathematical ideas would, however, be overwhelming if they were not compensated by some simplification in the process actually employed. Of these aids to calculation I will mention only two—viz., symmetry of form and mechanical appliances, or say, mathematics as a fine art, and mathematics as a handicraft. And first as to symmetry of form. There are many passages of algebra in which long processes of calculation at the outset seem unavoidable. Results are often obtained in the first instance through a tangled maze of formulæ, where at best we can just make sure of our process step by step, without any general survey of the path which we have traversed, and still less of that which we have to pursue. But almost within our own generation a new method has been devised to clear this entanglement. More correctly speaking, the method is not new, for it is inherent in the processes of algebra itself, and instances of it, unnoticed, perhaps, or disregarded, are to be found cropping up throughout nearly all mathematical treatises. By Lagrange, and to some extent also by Gauss, among the older writers, the method of which I am speaking was recognized as a principle; but besides these, perhaps no others can be named until a period within our own recollection. The method consists in symmetry of expression. In algebraical formulæ combinations of the quantities entering therein occur and recur; and by a suitable choice of these quantities the various combinations may be rendered symmetrical, and reduced to a few well-known types. This having been done, and one such combination having been calculated, the remainder, together with many of their results, can often be written down at once, without further calculations, by simple permutations of the letters. Symmetrical expressions, moreover, save as much time and trouble in reading as in writing. Instead of wading laboriously through a series of expressions which although successively dependent, bear no outward resemblance to one another, we may read off symmetrical formulæ of almost any length at a glance. A page of such formulæ becomes a picture: known forms are seen in definite groupings; their relative positions or perspective, as it may be called, their very light and shadow, con-

vey their meaning almost as much through the artistic faculty as through any conscious ratiocinative process. Few principles have been more suggestive of extended ideas or of new views and relations than that of which I am now speaking. In order to pass from questions concerning plane figures to those which appertain to space, from conditions having few degrees of freedom to others which have many—in a word, from more restricted to less restricted problems, we have in many cases merely to add lines and columns to our array of letters or symbols already formed, and then read off pictorially the extended theorems.

Next as to mechanical appliances. Mr. Babbage, when speaking of the difficulty of insuring accuracy in the long numerical calculations of theoretical astronomy, remarked that the science which in itself is the most accurate and certain of all had, through these difficulties, become inaccurate and uncertain in some of its results. And it was doubtless some such consideration as this, coupled with his dislike of employing skilled labour where unskilled would suffice, which led him to the invention of his calculating machines. The idea of substituting mechanical for intellectual power has not lain dormant; for besides the arithmetical machines whose name is legion (from Napier's bones, Earl Stanhope's calculator, to Schultz and Thomas's machines now in actual use) an invention has lately been designed for even a more difficult task. Professor James Thomson has, in fact, recently constructed a machine which, by means of the mere friction of a disk, a cylinder, and a ball, is capable of effecting a variety of the complicated calculations which occur in the highest application of mathematics to physical problems.[19] By its aid it seems that an unskilled labourer may, in a given time, perform the work of 10 skilled arithmeticians. The machine is applicable alike to the calculation of tidal, of magnetic, of meteorological, and perhaps also of all other periodic phenomena. It will solve differential equations of the second and perhaps of even higher orders. And through the same invention the problem of finding the free motions of any number of mutually attracting particles, unrestricted by any of the approximate suppositions required in the treatment of the lunar and planetary theories, is reduced to the simple process of turning a handle.

When Faraday had completed the experimental part of a physical problem, and desired that it should thenceforward be treated mathematically, he used irreverently to say, "Hand it over to the calculators." But truth is ever stranger than fiction; and if he had lived until our day he might with perfect propriety have said, "Hand it over to the machine."

Had time permitted, the foregoing topics would have led me to point out that the mathematician, although concerned only with abstractions, uses many of the same methods of research as are employed in other sciences, and in the arts, such as observation, ex-

19 "Royal Society's Proceedings," February 3, 1876, and May 9, 1878.

periment, induction, imagination. But this is the less necessary because the subject has been already handled very ably, although with greater brevity than might have been wished, by Professor Sylvester in his address to Section A at our meeting at Exeter. In an exhaustive treatment of my subject there would still remain a question which in one sense lies at the bottom of all others, and which through all time has had an attraction for reflective minds—viz., what was the origin of mathematical ideas? Are they to be regarded as independent of, or dependent upon, experience? The question has been answered sometimes in one way and sometimes in another. But the absence of any satisfactory conclusion may after all be understood as implying that no answer is possible in the sense in which the question is put, or rather that there is no question at all in the matter, except as to the history of actual facts. And even if we distinguish, as we certainly should, between the origin of ideas in the individual and their origin in a nation or mankind, we should still come to the same conclusion. If we take the case of the individual, all we can do is to give an account of our own experience; how we played with marbles and apples; how we learnt the multiplication table, fractions, and proportion; how we were afterwards amused to find that common things conformed to the rules of number; and later still how we came to see that the same laws applied to music and to mechanism; to astronomy, to chemistry, and to many other subjects. And then, on trying to analyze our own mental processes, we find that mathematical ideas have been imbibed in precisely the same way as all other ideas—viz., by learning, by experience, and by reflection. The apparent difference in the mode of first apprehending them and in their ultimate cogency arises from the differences of the ideas themselves, from the preponderance of quantitative over qualitative considerations in mathematics, from the notions of absolute equality and identity which they imply.

If we turn to the other question—How did the world at large acquire and improve its idea of number and of figures? How can we span the interval between the savage who counted only by the help of outward objects, to whom 15 was "half the hands and both the feet," and Newton or Laplace?—the answer is the history of mathematics and its successive developments—arithmetic, geometry, algebra, &c. The first and greatest step in all this was the transition from number in the concrete to number in the abstract. This was the beginning not only of mathematics but of all abstract thought. The reason and mode of it was the same as in the individual. There was the same general influx of evidence, the same unsought for experimental proof, the same recognition of general laws running through all manner of purposes and relations of life. No wonder then if, under such circumstances, mathematics, like some other subjects, and perhaps with better excuse, came after a time to be clothed with mysticism; nor that, even in modern times, they should

have been placed upon an *à priori* basis, as in the philosophy of Kant. Number was soon found to be a principle common to so many branches of knowledge that it was readily assumed to be the key to all. It gave distinctness of expression, if not clearness of thought, to ideas which were floating in the untutored mind, and even suggested to it new conceptions. In "the one," "the all," "the many in one," terms of purely arithmetical origin, it gave the earliest utterances to men's first crude notions about God and the world. In "the equal," "the solid," "the straight," and "the crooked," which still survive as figures of speech among ourselves, it supplied a vocabulary for the moral notions of mankind, and quickened them by giving them the power of expression. In this lies the great and induring interest in the fragments which remain to us of the Pythagorean philosophy.

The consecutive processes of mathematics led to the consecutive processes of logic; but it was not until long after mankind had attained to abstract ideas that they attained to any clear notion of their connexion with one another. In process of time the leading ideas of mathematics became the leading ideas of logic. The "one" and the "many" passed into the "whole" and its "parts;" and thence into the "universal" and the "particular." The fallacies of logic, such as the well-known puzzle of Achilles and the tortoise, partake of the nature of both sciences. And perhaps the conception of the infinite and *infinitesimal,* as well as of negation, may have been in early times transferred from logic to mathematics. But the connexion of our ideas of number is probably anterior to the connexion of any of our other ideas. And, as a matter of fact, geometry and arithmetic had already made considerable progress when Aristotle invented the syllogism.

General ideas there were, beside those of mathematics—true flashes of genius which saw that there must be general laws to which the universe conforms, but which saw them only by occasional glimpses and through the distortion of imperfect knowledge; and although the only records of them now remaining are the inadequate representations of later writers, yet we must still remember that to the existence of such ideas is due not only the conception, but even the possibility of physical science. But these general ideas were too wide in their grasp, and in early days at least were connected to their subjects of application by links too shadowy to be thoroughly apprehended by most minds; and so it came to pass that one form of such an idea was taken as its only form, one application of it as the idea itself; and philosophy, unable to maintain itself at the level of ideas, fell back upon the abstractions of sense, and by preference, upon those which were most ready to hand—namely, those of mathematics. Plato's ideas relapsed into a doctrine of numbers; mathematics into mysticism into neo-Platonism, and the like. And so, through many long ages, through good report and evil report, mathematics have always held an unsought-for sway

It has happened to this science, as to many other subjects, that its warmest adherents have not always been its best friends. Mathematics have often been brought into matters where their presence has been of doubtful utility. If they have given precision to literary style, that precision has sometimes been carried to excess, as in Spinoza and perhaps Descartes; if they have tended to clearness of expression in philosophy, that very clearness has sometimes given an appearance of finality not always true; if they have contributed to definition in theology, that definiteness has often been fictitious, and has been attained at the cost of spiritual meaning. And, coming to recent times, although we may admire the ingenuity displayed in the logical machines of Earl Stanhope and of Stanley Jevons,[20] in the "Formal Logic," of De Morgan, and in the "Calculus" of Boole;[21] although as mathematicians we may feel satisfaction that these feats (the possibility of which was clear *à priori*) have been actually accomplished, yet we must bear in mind that their application is really confined to cases where the subject-matter is perfectly uniform in character, and that beyond this range they are liable to encumber rather than to assist thought.

Not unconnected wlth this intimate association of ideas and their expression is the fact that, whichever may have been cause, whichever effect, or whether both may not in turn have acted as cause and effect, the culminating age of classic art was contemporaneous with the first great development of mathematical science. In an earlier part of this discourse I have alluded to the importance of mathematical precision recognized in the technique of art during the Cinquecento; and I have now time only to add that on looking still further back it would seem that sculpture and painting, architecture and music, nay, even poetry itself, received a new, if not their first, true impulse at the period when geometric form appeared fresh chiselled by the hand of the mathematician, and when the first ideas of harmony and proportion rang joyously together in the morning tide of art.[22]

Whether the views on which I

20 For example, in Herbert's "Psychologie."

21 A specimen will be found in the "Moralia," of Gregory the Great, Lib. I., c. xiv., of which I quote only the arithmetical part:—

"Quid in septenario numero, nisi summa perfectionis accipitur? Ut enim humanæ rationis causas de septenario numero taceamus, quæ afferunt, quòd idcirco perfectus sit, quia exprimo pari constat, et primo, impari; ex primo, qui dividi potest, et primo, qui dividi non potest; certissimè scimus, quòd septenarium numerum Scriptura Sacra pro perfectione ponere consuevit. . . . A septenario quippe numero in duodenarium surgitur. Nam septenarius suis in se partibus multiplicatus, ad duodenarium tenditur. Sive enim quatuor per tria, sive per quatuor tria ducantur, septem in duodecim vertuntur. . . . Jam superiùs dictum est quòd in quinquagenario numero, qui septem hebdomadibus ac monade additâ impletur, requies designatur; denario autem numero summa perfectionis exprimetur."

22 Approximate dates B.C. of Sculptors, Painters, and Poets.—Stesichorus, 600; Pindar, 522—442; Æschylus, 500—450; Sophocles, 495—400; Euripides, 480—400; Phidias, 488—432; Praxiteles, 450—400; Zeuxis, 400; Apelles, 350; Scopas, 350. Mathematicians.—Thales, 600; Pythagoras, 500; Anaxagoras, 500—450; Hippocrates, 460; Theætetus, 440; Archytas, 400; Euclid, 323—283.

have here insisted be in any way novel, or whether they be merely such as from habit or from inclination are usually kept out of sight, matters little. But whichever be the case, they may still furnish a solvent of that rigid aversion which both literature and art are too often inclined to maintain towards science of all kinds. It is a very old story that to know one another better, to dwell upon similarities rather than upon diversities, are the first stages towards a better understanding between two parties; but in few cases has it a truer application than in that here discussed. To recognize the common growth of scientific and other instincts until the time of harvest is not only conducive to a rich crop, but it is also a matter of prudence, lest in trying to root up weeds from among the wheat, we should at the same time root up that which is valuable as wheat. When Pascal's father had shut the door of his son's study to mathematics, and closeted him with Latin and Greek, he found on his return that the walls were teeming with formulæ and figures, the more congenial products of the boy's mind. Fortunately for the boy, and fortunately also for science, the mathematics were not torn up, but were suffered to grow together with other subjects. And, all said and done, the lad was not the worse scholar or man of letters in the end. But, truth to tell, considering the severance which still subsists in education, and during our early years between literature and science, we can hardly wonder if when thrown together in the afterwork of life they should meet as strangers, or if the severe garb, the curious implements, and the strange wares of the latter should seem little attractive when contrasted with the light companionship of the former. The day is yet young, and in the early dawn many things look weird and fantastic which in fuller light prove to be familiar and useful. The outcomings of science, which at one time have been deemed to be but stumbling-blocks scattered in the way, may ultimately prove stepping-stones which have been carefully laid to form a pathway over difficult places for the children of "sweetness and light."

The instances on which we have dwelt are only a few out of many in which mathematics may be found ruling and governing a variety of subjects. It is as the supreme result of all experience, the framework in which all the varied manifestations of nature have been set, that our science has laid claim to be the arbiter of all knowledge. She does not, indeed, contribute elements of fact, which must be sought elsewhere; but she sifts and regulates them; she proclaims the laws to which they must conform if those elements are to issue in precise results. From the data of a problem she can infallibly extract all possible consequences, whether they be those first sought, or others not anticipated; but she can introduce nothing which was not latent in the original statement. Mathematics cannot tell us whether there be or not limits to time or space; but to her they are both of indefinite extent, and this in a sense which neither

affirms nor denies that they are either infinite or finite. Mathematics cannot tell us whether matter be continuous or discrete in its structure; but to her it is indifferent whether it be one or the other, and her conclusions are independent of either particular hypothesis. Mathematics can tell us nothing of the origin of matter, of its creation or its annihilation; she deals only with it in a state of existence; but within that state its modes of existence may vary from our most elementary conception to our most complex experience. Mathematics can tell us nothing beyond the problems which she specifically undertakes; she will carry them to their limit, but there she stops, and upon the great region beyond she is imperturbably silent.

Conterminous with space and coeval with time is the kingdom of mathematics; within this range her dominion is supreme; otherwise than according to her order nothing can exist; in contradiction to her laws nothing takes place. On her mysterious scroll is to be found written for those who can read it that which has been, that which is, and that which is to come. Everything material which is the subject of knowledge has number, order, or position; and these are her first outlines for a sketch of the universe. If our more feeble hands cannot follow out the details, still her part has been drawn with an unerring pen, and her work cannot be gainsaid. So wide is the range of mathematical science, so indefinitely may it extend beyond our actual powers of manipulation, that at some moments we are inclined to fall down with even more than reverence before her majestic presence. But so strictly limited are her promises and powers, about so much that we might wish to know does she offer no information whatever, that at other moments we are fain to call her results but a vain thing, and to reject them as a stone when we had asked for bread. If one aspect of the subject encourages our hopes, so does the other tend to chasten our desires; and he is perhaps the wisest, and in the long run the happiest among his fellows, who has learnt not only this science, but also the larger lesson which it indirectly teaches—namely, to temper our aspirations to that which is possible, to moderate our desires to that which is attainable, to restrict our hopes to that of which accomplishment, if not immediately practicable, is at least distinctly within the range of conception. That which is at present beyond our ken may, at some period and in some manner as yet unknown to us, fall within our grasp; but our science teaches us, while ever yearning with Goethe, for "Light, more light," to concentrate our attention upon that of which our powers are capable, and contentedly to leave for future experience the solution of problems to which we can at present say neither yea or nay.

It is within the region thus indicated that knowledge in the true sense of the word is to be sought. Other modes of influence there are in society and in individual life, other forms of

energy besides that of intellect. There is the potential energy of sympathy, the actual energy of work; there are the vicissitudes of life, the diversity of circumstances, health, and disease, and all the perplexing issues, whether for good or for evil, of impulse and of passion. But although the Book of Life cannot at present be read by the light of science alone, nor the wayfarers be satisfied by the few loaves of knowledge now in our hands, yet it would be difficult to overstate the almost miraculous increase which may be produced by a liberal distribution of what we already have, and by a restriction of our cravings within the limits of possibility.

In proportion as method is better than impulse, deliberate purpose than erratic action, the clear glow of sunshine than irregular reflection, and definite utterances than an uncertain sound; in proportion as knowledge is better than surmise, proof than opinion, in that proportion will the mathematician value a discrimination between the certain and the uncertain, and a just estimate of the issues which depend upon one motive power or the other. While on the one hand he accords to his neighbours full liberty to regard the unknown in whatever way they are led by the noblest powers that they possess, so on the other he claims an equal right to draw a clear line of demarcation between that which is a matter of knowledge and that which is, at all events, something else, and to treat the one category as fairly claiming our assent, the other as open to further evidence. And yet, when he sees around him those whose aspirations are so fair, whose impulses so strong, whose receptive faculties so sensitive, as to give objective reality to what is often but a reflex from themselves, or a projected image of their own experience, he will be willing to admit that there are influences which he cannot as yet either fathom or measure, but whose operation he must recognise among the facts of our existence.

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THE END.

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